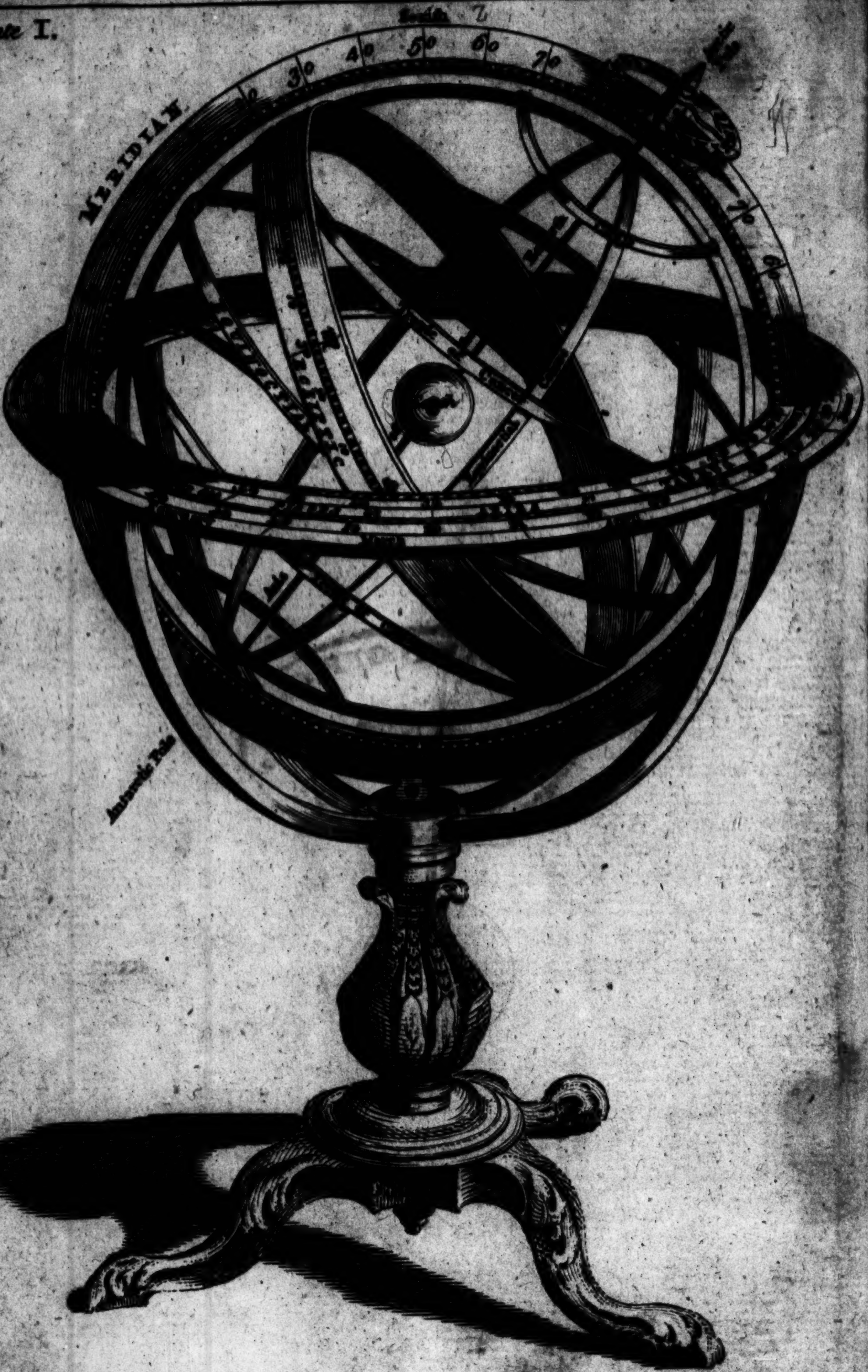
The ARMILLARY SPHERE.

Plate I.



Eman.^l Bowen Sculp.^t

The ARMILLARY SPHERE.

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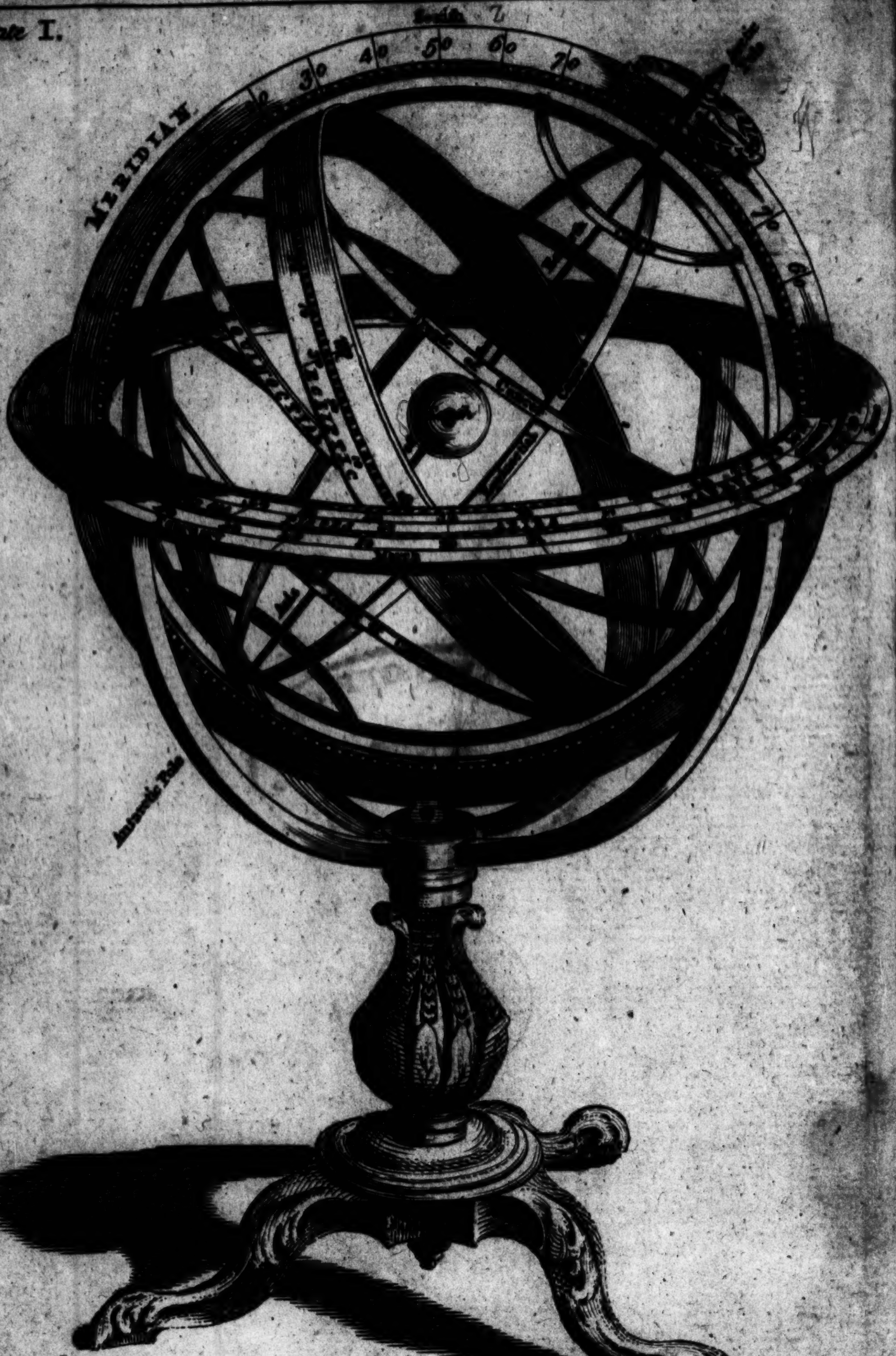

Eman.l Bowen Sculp.t

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Geo: Nash

THE DESCRIPTION and USE OF BOTH THE GLOBES, THE ARMILLARY SPHERE, AND ORRERY,

EXEMPLIFIED

In a large and ſelect Variety of Problems in

ASTRONOMY, GEOGRAPHY, DIALLING,
NAVIGATION, Spherical TRIGONOMETRY,
CHRONOLOGY, &c.

ALSO,

A NEW CONSTRUCTION of each GLOBE, by an Apparatus exhibiting the Phænomena of the Earth and Heavens exactly as they are, and adapting the ſame to every Age of the World.

The Whole embelliſhed with FIVE COPPER PLATES of the INSTRUMENTS, &c.

By BENJ. MARTIN.

LONDON:
Printed for, and Sold by the Author in *Fleetſtreet.*

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PREFACE.

T*HE Neceſſity of the Knowledge of the Uſe of the* Globes, Sphere, *and* Orrery, *for an eaſy Conception and due Underſtanding of the firſt Principles of* Geography, Aſtronomy, Dialling, Navigation, Chronology, *and other liberal Sciences, is known to every one; and is of the firſt Conſideration among thoſe Qualities requiſite for forming the* SCHOLAR *and the* GENTLEMAN.

The Invention of theſe Inſtruments lies very high in Antiquity; that of the Armillary Sphere *is not certainly known; ſome aſcribe it to* Atlas, *others to* Muſæus, Anaximander, Poſidonius, *&c. We meet with ſome Hints of the* Celeſtial Globe *as early as* Hipparchus's *Time, from the Writings of* Pliny *and* Ptolomy. *And* Strabo *mentions the* Terreſtrial Globe; *and* Propertius *(who lived about his Time) ſpeaks directly of* depicted Worlds;

Cogor et è Tabula pictos ediſcere Mundos.

And Claudian's *Deſcription of* Archimedes's Sphere *in Glaſs leaves no Room to doubt of the extreme Accuracy to which the Knowledge of the Conſtruction* *and Uſe of an* Orrery *had arrived in the Time of that great Mathematician.*

Amongſt the Improvers and Makers of modern Globes we find the following of the firſt Claſs, viz. Tycho Brahe, Regiomontanus, Schonerus, Gemma Friſius, Ger. Mercator, J. Hondius, Johnſonius, William Saunderſon, William Bleau, *&c. many of whom wrote, alſo, very learnedly of their Uſes; but in this Reſpect we muſt give the Preference to our own Countryman* Robert Hues, *whoſe* Latin Treatiſe *was afterwards publiſhed by* Hondius, *and then by* Pontanus *with Figures and large Notes; which were tranſlated into* Engliſh *by* J. Chilmead *in the Year* 1639.

But as no former Globes were ever conſtructed with ſo much exquiſite Skill, Taſte, and Elegance as thoſe of the late Mr. Senex, *F. R. S. (now known and celebrated to the remoteſt Limits of the* literary World,) *and ſince it has been lately my Province to make and ſell theſe Globes with many Corrections and Improvements; I thought it would be very agreeable to the Public to have a Treatiſe of the* Uſes *of* Globes *particularly adapted to them, as Mr.* Senex *himſelf has left us nothing of his own upon the Subject; and this is the general Reaſon of the preſent Publication.*

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Page 81, *Line* 8, *for* Meridian, *read* Horizon.

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CHAP. I.

DEFINITIONS *and* PRINCIPLES *neceſſary to be premiſed to the* USE *of the* GLOBES. *Of the* FRAMES, EXTERIOR CIRCLES, *and other* APPARATUS.

2.2.04.

Definition I.

AN *artificial* GLOBE is a round ſolid Body, having every Part of its Surface equally diſtant from a Point within it, called, its *Centre*. This, indeed, is rather a geometrical, than a geographical Definition of a Globe; becauſe our artificial Globes are rather ſolid Surfaces, than ſolid Spheres, as they are for the greateſt Part hollow within-ſide.

Def. II. A SPHERE is the ſame with a Globe, in a geometrical Senſe of the Word, whether ſuperficial or ſolid; but an *Armillary* SPHERE is that which conſiſts of Circles only, properly put together, without any continued or entire Surface.

Of artificial Globes there are two Sorts, one called the *Celeſtial Globe*, and the other *Terreſtrial*.

Def. III. The CELESTIAL GLOBE is that which has on its Surface a proper Repreſentation of all the viſible Stars in the Heavens, and the Images or Figure of the various Conſtellations into which thoſe Stars are arranged.

Def. IV. The TERRESTRIAL GLOBE is an artificial Repreſentation of all the Parts of Land and Water which conſtitute the Surface of the real Globe of the Earth in their proper Quantity, Form, Situation, and all other Circumſtances.

To render theſe Globes uſeful, they are diſpoſed in Frames, and turned round an Axis ſo as to repreſent the diurnal Motion of the Earth and Heavens. They are alſo moveable in another Reſpect, ſo as to have any Part raiſed or depreſſed in a vertical Manner.

Def. V. The AXIS of a Globe, or Circle, is that Right Line which paſſes through the Center, and about which it revolves.

Def. VI. The POLES of a Globe are the two extreme Parts of the Axis in the Surface of the Globe.

Def. VII. A GREAT CIRCLE of a Globe, or Sphere, is that which divides it into two equal Parts.

Def.

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Def. VIII. A *ſmall* CIRCLE is that which divides the Surface of a Globe, or Sphere, into two unequal Parts.

Def. IX. PARALLELS, or *ſecondary Circles*, are ſuch ſmall Circles on the Surface of the Globe, or Sphere, as are every where equally diſtant from their correſponding great Circle.

Def. X. A DEGREE is the 360th Part of a Circle, ſo that every Circle, *great* or *ſmall*, is underſtood to be divided into 360 of thoſe equal Parts, or Degrees; and each one of thoſe Degrees is ſuppoſed to be ſubdivided into 60 equal Parts called *Minutes*, and each Minute is again divided into 60 equal Parts called *Seconds*, and ſo on to *Thirds*, *Fourths*, *&c.*

Def. XI. The POLE of any Circle in the Surface of a Globe, or Sphere, is a Point every way equally diſtant from it: conſequently, the Pole of a GREAT *Circle* is every where at the Diſtance of *ninety* Degrees.

In order that the Globes may anſwer, in the beſt Manner, every Purpoſe they are deſigned for, 'tis neceſſary they ſhould move within various Circles circumſcribed without them, which may be called exterior, or *moveable Circles*; and alſo to have other Circles drawn on their Surfaces, as the Rules of Art require, which therefore may be conſidered, or diſtinguiſhed as *fixed Circles.*—

Theſe Circles of the Globe, or Sphere, are to be conceived as correſponding to the ſame Circles ſuppoſed to be ſituated in ſimilar Parts of the concave Surface of the Heavens, or upon and about the convex Surface of the Earth, which therefore are called the *imaginary Circles* of the Sphere: by Means of theſe Circles the various Parts of the Heavens and the Earth, together with their different Phænomena, may, by Means of the artificial Globe, be rendered very eaſy to be conceived and underſtood.

The exterior, or moveable Circles, are thoſe which follows:

Def. XII. The *wooden* HORIZON is the upper Part of the Frame, and is that broad Circle, whoſe upper Side repreſents the Horizon of the Place, and is divided into ſeveral Circles, the innermoſt of which contains the twelve Signs of the *Zodiack*, diſtinguiſhed by their Names and Characters; and each Sign is divided into 30 Degrees: next to this are two Circles, with the *Julian* and *Gregorian* Kalendars diſpoſed according to their Months, and Days. The outermoſt is a Circle with all the Points of the Compaſs, or the Winds, as they are denominated by Sea-Men.

Def. XIII. *Cardinal* POINTS are the four principal Points of the Horizon, which are called *South*, *Eaſt*, *North*, and *Weſt*. From hence, that Pole of the Globe which is turned towards the North Point of the Horizon is called, the *North Pole*; and, of Courſe, that which is oppoſite to it muſt be the *South Pole*.

Def. XIV. The ZENITH is the uppermoſt Pole of the Horizon, or it is the moſt elevated Point on the Surface of the Globe, in which the Eye of the Spectator is ſuppoſed to be placed: or in the Heavens, it is the Point perpendicularly over ones Head, as this artificial Horizon correſponds with that great Circle which bounds our Sight in the Heavens, and in which all the heavenly Bodies are ſaid to *riſe* and *ſet* when they aſcend above, or deſcend below it.

Def. XV. The NADIR is the lower Pole of the Horizon, and therefore is a Point in the Surface of the Globe diametrically oppoſite to the Zenith.

Def. XVI. The AMPLITUDE of ye Sun, or Stars, &c. is the Diſtance in Degrees, of their Rising or Setting reckoned from the Eaſt or Weſt Point of the Horizon, towards the South or North, and is diſtinguiſhed into the *Ortive* and *Occaſive*, of the Amplitude at the *riſing* and *ſetting* of any heavenly Body.

Def. XVII. The ALMICANTHERS are ſmall Circles, parallel to the Horizon, and are called *Parallels* of *Altitude*.

Def. XVIII. The *general*, or *Brazen* MERIDIAN, is that large Braſs Circle in which the Globe is ſuſpended by the Ends of the Axis produced, and is voluble about it: It has its Name from repreſenting that Circle in the Heavens, or on the Surface of the Earth, where the Sun is at the Moment of Noon, or twelve o'Clock, (becauſe Noon, in *Latin*, is called *Meridies*, or Mid-day.) This Circle is divided, on that Side facing the Eaſt Point of the Horizon, into four Quarters, containing ninety Degrees each, which Diviſion begins on the middle Point between the Poles on the upper or ſouthern Half of the Meridian, and is numbered each Way towards either Pole; but in the other Half the Meridian, the Degrees are numbered from the Pole towards the middle Point. This Meridian is ſupported, and moveable on a Braſs Roller, or Wheel, fixed on the Pedeſtal, or Baſe of the Frame, as alſo in two Notches cut in the South and North Points of the Horizon, by which Means the Poles of the Globe are elevated or depreſſed, alternately, to any Altitude, or Number of Degrees above the Horizon required.

Def. XIX. The *Quadrant* of ALTITUDE is a thin Slip of Braſs, whoſe Edge is divided into ninety Degrees; and it is contrived to be moveable on the Braſs Meridian, and to be fixed to any Part by a Nut and Screw: Of Courſe, when it is fixed to the Zenith, or Pole, of the Horizon, it will ſerve to meaſure any Altitude of any Phænomenon above the Horizon; becauſe the Diviſions begin at the Horizon, and are reckoned upwards on the Quadrant.

Def. XX. *A Vertical* Circle is a great Circle of a Sphere, which paſſeth through the Poles of the Horizon, or turns upon the Zenith and Nadir Points; and that which paſſes through the Eaſt and Weſt Points of the Horizon is called, the *prime Vertical*, or the Principal of them all. Hence it is eaſy to underſtand that the Quadrant of Altitude, fixed on the Zenith Point of the Meridian, will indifferently, and generally repreſent any of thoſe vertical Circles in its Motion about the ſaid Point, or Pole of the Horizon.

Def. XXI. The Azimuth is the Quantity of that Angle contained between a vertical Circle and the Meridian, reckoned or meaſured in Degrees of a Circle on the Horizon, from the North or South Points to the Eaſt or Weſt. The Quadrant of Altitude therefore, being laid over any particular Place on the Surface of either Globe, will ſhew its Azimuth on the Horizon.

Def. XXII. The Semi-circle of *Poſition*, is that whoſe Extremities are fixed to the North and South Points of the Horizon, ſo that it can be moved freely from the Horizon to the Meridian, or be placed in any Poſition between them: But as we have little to do with this Semi-circle in the general Uſe of the Globe, and is attended with Expence and Incumberance, it is not uſually made with the Globe, unleſs beſpoke.

Def. XXIII. The HOUR-CIRCLE is a ſmall Circle fixed on the Braſs Meridian, with the Pole of the Globe in its Center: It is divided into twice twelve Hours: The twelfth Hour, at Noon, is upon the upper Part of it, at the Meridian; and the XII at Night is on the Meridian, at the lower Part towards the Horizon. The Axis of the Globe, projecting above the Braſs Meridian, carries round the Index, or Hand, which ſhews the Hour, and is eaſily moveable, on the ſaid Axis, to any Hour propoſed, when the Globe is held at Reſt.

Def. XXIV. The MARINERS COMPASS is a Box containing a magnetical Needle, freely moving on a fine Point, in the Center of a Circle divided into four times ninety Degrees, reckoning from the North and South towards Eaſt and Weſt; and alſo into the thirty-two Points of the Compaſs, properly marked: As this Needle has the Property of making a certain conſtant Angle with the Meridian in every Place, which Angle is called the *Variation*, therefore this Compaſs, being added to the Frame, will ſhew the Poſition of the Meridian when the Variation of the Needle is known. Thus, at *London*, the Variation is at this time *nineteen Degrees* Weſtward; therefore, by moving the Frame of the Globe one Way, or the other, 'till the Needle ſettles itſelf over the nineteenth Degree, reckoned Weſtward from the North Point, or *Flower-de-Luce*, we ſhall have the Braſs Meridian exactly coinciding with the true Meridian of *London*.

N.B. In June 1781 — the Variation was 22 Deg^{s}. 41 Min^{s}. Westward

* * *

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CHAP. II.

Of the CIRCLES *delineated on the* SURFACES *of the* GLOBES, *and their various Uſes.*

* * *

On the Surfaces of the Globe are delineated the following Circles.

Definition XXV.

THE EQUINOCTIAL on the Celeſtial, or the EQUATOR on the terreſtrial Globe, is that great Circle whoſe Plane divides the Globe into two equal Parts, *viz.* the Northern and Southern Hemiſpheres, whoſe Poles are the Poles of the Globe itſelf. It is divided into 360 Degrees, reckoned Eaſtward quite round to the Point where they begin.

Def. XXVI. RIGHT ASCENSION is that Degree, or Point of the Equinoctial Line, which is upon the Meridian, with any Phænomenon in the Heavens upon the celeſtial

Globe; and this is called *right Aſcenſion* in *Motion*.

Def. XXVII. RIGHT ASCENSION in TIME, is the right Aſcenſion in Motion converted into Time by allowing 15° to an Hour; for as the Globe revolves on its Axis in XXIV Hours, there muſt, in each Hour, paſs under the Meridian 15° of the Equinoctial Line; and, conſequently, every Degree will Anſwer to four Minutes of Time, and 15′ of a Degree to one Minute of Time, 15″ of a Minute of a Degree to one Second of a Minute in Time, and ſo on: ſo that the Time in which any Motion in the Equinoctial, or Equator, is performed, will be eaſily known by a Table hereafter inſerted.

Def. XXVIII. OBLIQUE ASCENSION is that Point of the Equinoctial which riſes with a Star, or other Phænomenon, in an oblique Sphere.

Def. XXIX. LONGITUDE, on the Terreſtrial Globe, is that Degree of the Equator which comes to the Meridian with any given Place; or it is the Diſtance Eaſt or Weſt of the Meridian of any Place from the firſt Point of the Equator: ſo, that Longitude on the Terreſtrial Globe is the ſame as right Aſcenſion in the Celeſtial, and is in the ſame Manner to be converted into Time.

Def. XXX. The DECLINATION is the Number of Degrees, rekoned in the Meridian,

dian, at which any Star is placed from the Equinoctial Line towards the North or South Pole.

Def. XXXI. The LATITUDE of a Place, on the Terreſtrial Globe, is, in like Manner, the Diſtance of a Place from the Equator, meaſured in Degrees of the Meridian, towards the North or South Pole.

Def. XXXII. PARALLELS of *Declination* and *Latitude*, are thoſe leſſer Circles which are drawn on the Surface of the Globe parallel to the Equinoctial, or Equator, on the Terreſtrial Globe; they are uſually drawn through every tenth Degree of Latitude.

Def. XXXIII. The ECLIPTIC is a great Circle, divided into twelve equal Parts called SIGNS, and each Sign contains thirty Degrees. Theſe take their Names from thoſe Conſtellations in the Heavens, through or near which they paſſed at the Time thoſe Names were given to them This Circle makes an Angle with the Equinoctial of about 23° 30′, which is called, the *Obliquity* of the Ecliptic. This Circle repreſents the annual Path of the Sun through the Heavens among the fixed Stars; and becauſe the *Eclipſes* muſt neceſſarily happen in this Line, where the Sun always is, it is therefore, called, the *Ecliptic*. The Names, Characters, and Order of the Signs of the Ecliptic are as follow:

Aries,

♈	*Aries*, or the Ram.
♉	*Taurus*, the Bull.
♊	*Gemini*, the Twins.
♋	*Cancer*, the Crab.
♌	*Leo*, the Lion.
♍	*Virgo*, the Virgin.
♎	*Libra*, the Balance.
♏	*Scorpio*, the Scorpion.
♐	*Sagittarius*, the Archer.
♑	*Capricornus*, the Goat.
♒	*Aquarius*, the Water-Bearer.
♓	*Piſces*, the Fiſhes.

The firſt ſix are called the *northern* Signs, as they lie on the Northern Hemiſphere; and the latter are the *Southern* Signs. By this Diviſion of the ecliptic Line, we can more readily point out the Sun's Place in the Heavens, for any given Time, by ſaying, *he is in ſuch a Degree of ſuch a Sign.*

Def. XXXIV. The Equinoctial Points are thoſe in which the Ecliptic and Equinoctial interſect each other, of which that is called, the *Vernal Equinox* when the Sun is in the Equinoctial Line in the *Spring*: and the other is called the *Autumnal Equinox*, as the Sun, at that Seaſon of the Year, croſſes the Equinoctial Line again. The beginning of the Ecliptic, as well as the Equinoctial Line, is at the Vernal Equinox; and, accordingly, the right Aſcenſion is reckoned from the firſt Point of Aries.

Def. XXXV. The LONGITUDE of a Star, or Planet, is its Diſtance from the firſt Point of *Aries* in the Ecliptic, reckoned in Signs, Degrees, Minutes, *&c.*

Def. XXXVI. The LATITUDE of a Star, or Planet, is its neareſt Diſtance from the Ecliptic, towards the Poles of the Ecliptic, on either Side, North or South: As the Ecliptic makes an Angle 23° 29′ with the Equinoctial, ſo the Poles of the Ecliptic will of Courſe be at the ſame Diſtance from the Poles of the World.

Def. XXXVII. CIRCLES of LATITUDE are thoſe great Circles which paſs through the Poles of the Ecliptic, and conſequently interſect the Ecliptic at right Angles. Theſe are peculiar to the Celeſtial Globe, and are uſually drawn through every 30°, dividing the whole Surface of the Globe into twelve equal Parts: By ſome Authors, theſe are alſo called *Circles of Longitude*, becauſe, being drawn thro' any Star, they reduce it to, and ſhew its Longitude in the Ecliptic.

Def. XXXVIII. The ZODIAC is a broad Space on the Surface of the Celeſtial Globe, extending to about 8° on each Side of the Ecliptic, in which are contained, the twelve *Aſteriſms*, or Conſtellations which give Names to the Signs; and becauſe moſt of theſe have the Likeneſs of ſome living Creature, this Space received the Name of *Zodiac*, which ſignifies a *Zone* of *Animals*. In this broad Circle are included, the Orbits of the Moon and all the Planets; and, as it is of the greateſt Uſe in practical Aſtronomy and Navigation, it has lately been put on Mr. *Senex's* Globes, and divided into each ſingle Degree of Latitude on either Side the Ecliptic.

Def. XXXIX. The TROPICS are thoſe Parallels of *Declination*, on the Celeſtial Globe, (of *Latitude* in the Terreſtrial) which touch the Ecliptic on either Side; and, becauſe one in the Northern Hemiſphere touches the Ecliptic in the Beginning of *Cancer*, it is called the *Tropic* of *Cancer*: for the ſame Reaſon, *that* which touches the Ecliptic in the Southern Hemiſphere is called the *Tropic* of *Capricorn*. The Word *Tropic* denotes a *Return*, becauſe, in thoſe Points, the Sun returns again to the Equinoctial.

Def. XL. The POLAR CIRCLES are thoſe Parallels of Declination (or Latitude in the Terreſtrial Globe) which circumſcribe the Poles of the World at the Diſtance of 23½ Degrees; or they are the Parallels of 66½ Degrees. That on the Celeſtial Globe, about the North Pole, paſſes through the Conſtellation called *Arctos*, or the *Bear*; from whence it is uſually called the *Arctic Circle*: and that which is oppoſite to it, about the South Pole, is called the *Antarctic Circle*. Both theſe and the Tropics are delineated on the Globes by double Lines, to diſtinguiſh them from other Parallels.

Def. XLI. The MERIDIANS are thoſe great Circles, on the Terreſtrial Globe, which paſs through, or interſect each other in the Poles of the World, and, of Courſe, are at right Angles to the Equator, where they determine the Longitude of Places through which they are drawn: one of theſe Meridians is called the FIRST MERIDIAN, from which the Reckoning in the Equator begins. The Poſition of this Meridian is arbitrary: But, to render the Globes more uſeful, we generally have two; one which paſſes through the Iſland of *Ferro*, and the other through the City of LONDON, as being the Capital of our own Country, and thereby ſaving us a great deal of Trouble in counting the Longitude of other Places. On large Globes, theſe Meridians are drawn thro' every tenth Degree; but in ſmall Ones, through every fifteenth Degree.

Def. XLII. HOUR CIRCLES are thoſe Meridians which paſs through every fifteenth Degree of the Equinoctial, on the Celeſtial Globe, dividing the Surface of the Globe into twenty-four equal Parts, each of which, therefore, paſſeth under the Brazen Meridian in the Space of one Hour, as we have hinted.

Def. XLIII. The SOLSTICES are thoſe Points of the Ecliptic which have the greateſt Declination, and conſequently the Beginning of *Cancer* and *Capricorn*: They are ſo called from the Sun appearing, as it were, *ſtationary* in thoſe Points, with reſpect to its Motion Northward and Southward; for its Declination alters but very little, or is ſcarcely ſenſible for many Days on one Side or the other of theſe Points, which are therefore called the *Solſtitial Points* of the Ecliptic.

Def. XLIV. The COLURES are thoſe two Meridians which paſs through the Equinoctial and Solſtitial Points, and conſequently croſs each other at right Angles in the Poles of the World: Hence one of them is called the *Equinoctial Colure*, and the other the *Solſtitial Colure*. Theſe Circles divide the Surface of the Globe into four equal Parts, denoting the four Seaſons of the Year.

Def. XLV. The RECESSION of the EQUINOXES is that ſlow Motion which the Equinoctial Points are, by long Obſervation, found to have from Eaſt to Weſt, contrary to the Order of the Signs, at the Rate of one Degree in 72 Years; and by this retrograde Motion of the Equinoctial Points, and conſequently of the Ecliptic, the Signs have departed from the Conſtellations in which they originally were, which has cauſed all thoſe Conſtellations to have an apparent Motion forward: and thus we find the Conſtellation of *Aries* is now (not in the Sign of that Name, but is) advanced forward into the ſecond Sign, taking the Place which *Taurus* formerly had, *Taurus* being now in *Gemini*, and ſo on; which is the Reaſon why you ſee the Conſtellations drawn as they are on the Celeſtial Globe. The phyſical Cauſe of all which is, our Earth, not being of a truly ſpherical Figure, but a little flatted at the Poles, cauſes a conical Motion in its Axis, which carries the Poles of the World round the Poles of the Ecliptic in the long Period of nearly 26,000 Years, which has been called the great *Platonic Year*.

Def. XLVI. An *Armillary* SPHERE is an aſtronomical Inſtrument, conſiſting of an artificial Diſpoſition of all the great and ſmall Circles of Note, before deſcribed, *viz.* the *Horizon*, the *Braſs Meridian*, the *Equinoctial*, the *Ecliptic* with the *Zodiac*, the *Equinoctial* and *Solſtitial Colures*, the *Tropics* and *Polar Circles*, the *Axis* of the *World* with the ſmall Hour Circle and Index; all which compages of Circles revolve, like the Globe, on the Axis of the World, and thereby greatly facilitate the Idea we ought to have of thoſe imaginary Circles in the Heavens, and their ſeveral Uſes: And, by Means of the Quadrant of Altitude, any ſpherical Triangle may be formed, and its Solution given by Inſpection; which renders this Inſtrument of great Utility in Aſtronomy, and the Uſe of the Globes; a Print of which we have therefore thought neceſſary to annex to theſe Definitions.

With reſpect to the Poſition of the Sphere, or Globe, there are the following Diſtinctions:

Def. XLVII. A *Parallel* SPHERE is that Poſition of it where the Equator coincides with the Horizon, and conſequently the Poles of the World are the *Zenith* and *Nadir* Points. The Parallels of Latitude here are all parallel to the Horizon; but there can be no ſuch Diſpoſition of the Sphere, but to an Inhabitant immediately under the Poles.

Def. XLVIII. A *right*, or *direct* SPHERE is that Poſition where the Equator and all its Parallels make *right Angles* with the Horizon. The Inhabitants of this Sphere are only thoſe who live under the Equinoctial Line.

Def. XLIX. An *Olique* SPHERE is when the Equinoctial makes an *oblique Angle* with the Horizon; and therefore is any other Poſition than the two former, and which every Inhabitant muſt have who does not live under the Equator and the Poles.

Def. L. The *Diurnal* ARCH is that Part of a Parallel of Declination which ſtands above the Horizon; the other Part, which is below it, is called the *Nocturnal Arch*.

Def. LI. *Aſcenſional* DIFFERENCE is the Difference in the *Aſcenſion* of an Object

above

above the Horizon, in a right or oblique *Sphere*; but in a right Sphere, every Celeſtial Phænomenon muſt riſe and ſet at the Diſtance of *ſix Hours*, from the Time of its being on the Meridian; therefore the aſcenſional Difference, turned into Time, ſhews how long it riſes or ſets before, or after the Hour of *ſix*.

N. B. A Table for converting any Number of Degrees of the Equinoctial (or Equator) into *Time* will be hereafter inſerted; by which the right or oblique Aſcenſion may be readily expreſſed in *Motion or Time*, as Occaſion requires.

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Chap. III.

Geographical *and* Aſtronomical Definitions *and* Principles *relative to the* Use *of the* Globes.

THE Surface of the Terreſtrial Globe conſiſts, as hath been ſaid, of Land and Water, very nearly in Proportion as one to three, which I have found, by weighing all thoſe Papers that repreſent the Land and Water, ſeparately, which cover Mr. *Senex*'s Terreſtrial Globe of 28 Inches Diameter. The Weight of the Paper for Land was 367 Grains, thoſe for the aqueous Surface weighed 1105 Grains, which Numbers give the Proportion above mentioned.

The Land is divided as follows:

I. A Continent is the largeſt Diviſion, or Extent of Land, comprehending diverſe Countries and Kingdoms not ſeparated by Water.

II. An ISLAND is any ſmall Tract of Land ſurrounded by Water.

III. A PENINSULA is a Part of Land encompaſſed with Water all around, except on one Part, which is called

IV. An ISTHMUS, being that narrow Neck of Land which joins it to the Continent.

V. A PROMONTORY is a mountainous Part of Land, ſtanding far out in the Sea, whoſe Fore-part is called

VI. A CAPE, or *Head*-Land.

The aqueous Part of the Surface of the Earth has the following Diſtinctions, or Diviſions:

I. The OCEAN is the largeſt Collection of Waters which lie between, and environs the Continents.

II. The SEA is a ſmaller Part of the aqueous Surface of the Earth, lying between the Iſlands, Promontories, *&c.*

III. A GULPH is a Part of the Sea every where environed with Land, except on one ſmall Part, called

IV. A STREIGHT, or STRAI[illegible], which is that narrow Paſſage joining it to the adjacent Sea.

V. A LAKE is any large Quantity of ſtagnant Water, entirely ſurrounded by Land.

Theſe ſeveral Denominations of Land and Water need no farther Account, or Deſcription, as a bare Inſpection of the Globe will preſent them ſufficiently to the View.

The moſt famous Diviſion of the Surface of the Earth, with regard to Heat and Cold, is into the five Zones, of which, one is called the *Torrid Zone*, two are called *Temperate Zones*, and the other two *Frigid Zones*.

I. The *Torrid* Zone is ſo called, from the Inhabitants being, as it were, *torrified* or ſcorched with the Sun's Heat; for this Part of the Earth is all that which lies between the two Tropics of *Cancer* and *Capricorn*, and over which the Ecliptic Line is obliquely poſited: from whence you will eaſily obſerve, that the Inhabitants of this Zone will have the Sun perpendicularly over their Heads, two Days in the Year, in paſſing from Tropic to Tropic, in each Half of the Ecliptic.

II. The *Temperate* Zones are all thoſe Parts of the terraqueous Globe which lie between the Tropics and Polar Circles; and conſequently there is one of theſe in the Northern, and one in the Southern Hemiſphere, as you may ſee very plainly on the Surface of the Globe. As we ourſelves are Inhabitants of the North Temperate Zone, we find the Seaſons of the Year in a temperate Degree: Our *Summer*

mer Suns are at a Diſtance from our *Zenith*; and we do not therefore experience the greateſt Force of his Beams. Again, we are never without his enlivening Influence the Space of one natural Day; ſo that, upon the whole, we muſt reckon our Situation the beſt that the Surface of the Earth can afford; the paradiſical Situation of *England* being the moſt temperate Part of the *Temperate Zone*.

III. The two *Frigid* ZONES are ſo called, becauſe of the exceſſive Cold in thoſe Parts: Theſe are improperly called *Zones*, being rather the Areas comprehended between the *Artic* and *Antarctic* Circles; but, as with a little Conſideration it will appear, that ſince one Half of the Year the Sun is above the Horizon, to the greateſt Part of thoſe *Zones* for many Days and Months together, without ſetting, they muſt have a very conſiderable Interval of warm, if not hot Seaſon; and, ſince the *Pole* itſelf is enlightened conſtantly for ſix Months together, it muſt be conſidered as the *hotteſt* at one Time, as well as the *coldeſt Part* at another, of the whole Earth.

There is another Diviſion of the Earth's Surface into what they call CLIMATES; but this was more in Uſe among ancient Geographers than the Modern: They called all that Part of the Earth, a *Climate*, which allowed an Increaſe of Half an Hour to a natural Day of 24, or the *firſt Climate*, extending from the Equator to that Parallel where the Day was $12\frac{1}{2}$ Hours long, from thence to the Parallel where the Day was 13 Hours, was called the *ſecond Climate*, and ſo on, through a Succeſſion of 24 *Climates*, till they came to the *Polar Circles*, where, the Sun not ſetting, the Day is 24 Hours long. Here they reckoned their Climates by monthly Illuminations, and ſo had ſix Climates within each *Frigid Zone*. But, to give a clearer Idea of this Matter, we ſhall give the following Table of *Climates*.

A TABLE *of the* CLIMATES.

CLIMATES *between the Equator and the Polar Circles.*

Climates.	Longest Day.	Latitude. D.	Latitude. M.	Breadth. D.	Breadth. M.	Climates.	Longest Day.	Latitude. D.	Latitude. M.	Breadth. D.	Breadth. M.
1	$12\frac{1}{2}$	8	25	8	25	13	$18\frac{1}{2}$	59	58	1	29
2	13	16	25	8	00	14	19	61	18	1	20
3	$13\frac{1}{2}$	23	50	7	25	15	$19\frac{1}{2}$	62	25	1	7
4	14	30	25	6	30	16	20	63	22	0	57
5	$14\frac{1}{2}$	36	28	6	8	17	$20\frac{1}{2}$	64	6	0	44
6	15	41	22	4	54	18	21	64	49	0	43
7	$15\frac{1}{2}$	45	29	4	7	19	$21\frac{1}{2}$	65	21	0	32
8	16	49	1	3	32	20	22	65	47	0	26
9	$16\frac{1}{2}$	51	58	2	57	21	$22\frac{1}{2}$	66	6	0	19
10	17	54	27	2	29	22	23	66	20	0	14
11	$17\frac{1}{2}$	56	37	2	10	23	$23\frac{1}{2}$	66	28	0	8
12	18	58	29	1	52	24	24	66	31	0	3

CLIMATES *between the Polar Circles and the Poles.*

Length of Days. Months.	Latitude. D.	Latitude. M.	Length of Days. Months.	Latitude. D.	Latitude. M.
1	67	21	4	78	30
2	69	48	5	84	5
3	73	37	6	90	00

There are ſome other Diſtinctions in Geography concerning the INHABITANTS of the Earth, in regard to their different Meridians or Parallels, *viz.* ſome are called the

PERIOECI, that live under the ſame Parallel, but, in the oppoſite Semi-circles of the ſame Meridian; both of them have the Seaſons of the Year the ſame; the Sun, by its annual apparent Motions, coming to, or receding from the Vertex of both Places at the ſame Time of the Year: but they change their Turns of Night and Day, ſo that when it is Mid-day to one, it is Mid-night to the other.

ANTOECI, are ſuch whoſe Habitations lie in the ſame Semi-circle of the Meridian, but in oppoſite Parallels, and both of them have Mid-day and Mid-night at the ſame Inſtant of Time: but the Seaſons of the Year are different, it being Summer to the one when it is Winter to the other.

Laſtly, the ANTIPODES, are thoſe whoſe Habitations being ſituated in both oppoſite Parallels, and oppoſite Meridians, have their *Feet directly oppoſite to one another* in a Line paſſing through the Center of the Earth; and they have not only their Days and Nights directly contrary, but alſo the Seaſons of the Year; when it is Summer in the one, it is Winter in the other Place, and when Mid-day in the firſt, the ſecond has Mid-night.

The Inhabitants likewiſe receive another Denomination from their *Shadows*, *viz.* the Inhabitants of the Torrid Zone, are called

The AMPHISCII, having their Meridian Shadows, at Different Times of the Year, projected towards *both Poles*; but when the Sun comes to be vertical to them, then they have no Shadow, and are called *Aſcii*, or ſhadowleſs, nothing that ſtands perpendicularly upwards, having a Shadow at Noon.

The HETEROSCII are thoſe who inhabit the Temperate Zone, as having the Meridian Shadow projected only towards *one Pole* throughout the whole Year.

The PERISCII are thoſe who inhabit the two Frigid Zones, ſo called, becauſe their Shadow turns *quite around* them in the Space of 24 Hours.

To theſe Definitions we may add, the Diſtinctions which the ancient Poets made, and are ſtill retained in the Writings of Aſtronomy, relative to the riſing and ſetting of the Stars, which they call the *Coſmical*, *Acronical*, and *Heliacal*.

The *Coſmical* riſing or ſetting of a Star, is when it riſes or ſets at the Time when the Sun riſes.

The *Acronical riſing* of the Star, is when it riſes when the Sun ſets.

The *Heliacal riſing*, is when the Star, or Planet emerges out of the Sun-beams, and is ſeen in a Morning before Sun riſing; and

it

it *ſets Heliacally* when it is ſo near the Sun-beams that it ceaſes to be ſeen.

Some other Definitions reſult from the Conſideration of the Motion of the Earth; that the Earth has a Motion about its Axis is well known, and becauſe we call the Time in which it makes one Revolution a DAY, therefore this is called the *diurnal Motion* of the Earth.

It is alſo well known, that the Direction of this Motion is from Weſt to Eaſt, or according to the Order of the Signs of the Ecliptic in which they *follow* one another; and therefore this, and all ſuch Motions are ſaid to be in *Conſequentia.*

This real Motion of the Earth, from Weſt to Eaſt, occaſions an apparent Motion of all the heavenly Bodies in a contrary Direction, or from Eaſt to Weſt, which is therefore ſaid to be in *Antecedentia.*

The Space of Time in which the Earth revolves upon its Axis is twenty-three Hours, fifty-ſix Minutes, three Seconds, and twenty-eight Thirds; in which Space of Time a fixed Star will make one complete Revolution: This Space of Time is therefore called the *Sidereal-Day.*

But the Time in which the Sun departs from the Meridian and returns to it again, or makes one Revolution, is called the *Solar-Day.* After the ſame Manner, we may conſider the Space of Time in which thoſe Meridian-Revolutions are performed by the Moon and Planets may, in like Manner, be called *Lunar* and *Planetary Days.*

ASTRONOMERS begin the Day at Noon, and call the natural Day, including common Day and Night, the *Nyćthemeron*; and they Number the Hours from one to twenty-four Hours ſucceſſively, and not by twice twelve, as the common Uſage is by Clocks.

The YEAR, with Aſtronomers, begins when the Sun enters the firſt Scruple of *Aries*, or the firſt Sign of the Ecliptic: but this Beginning of the Year cannot, on that Account, be ſtable, or fixed; becauſe, as we have before obſerved, the Equinoctial Points have a ſlow Motion in *Antecedentia*, or contrary to the Order of the Signs: Therefore the Sun, which moves in a contrary Direction, or in *Conſequentia*, will arrive at the vernal Equinox ſooner, each Year, than it would have done, had that Point been fixed: conſequently, the Moment of Time in which the Sun enters the vernal Equinox will happen a little Matter ſooner, every Year, than it did in the preceding Year, *viz.* by about twenty Minutes. The Time of this vernal Equinox will therefore conſtantly go forward in Time, (as the Equinoctial Point itſelf goes backward) and this is what is ſo frequently called, the *Preceſſion* of the *Equinox*.

The *Places* in which the heavenly Bodies appear, as viewed from the Earth or Sun, are differently denominated: The Place of a Planet when viewed from the Earth, is called the *Geocentric* Place; but when it is viewed from the Sun, it is called the *Heliocentric* Place. Accordingly, in the *Ephemeris*, (which ought ever to be at Hand when the Globes are in Uſe) theſe Places are properly tabulated, the *Geocentric* Places of the Sun, Moon, and Planets, for every Day of the Month through the Year; and the *Heliocentric* Places for every fifth Day only.

The *Geocentric Places* we have regard to in the Uſe of the Globes, and the *Heliocentric* become neceſſary in the Uſe of the Orrery. The Difference between the *Geocentric*, and the *Heliocentric* Place of a Planet, is equal to the Quantity of the Angle under which the Radius of the Earth's Orbit is ſeen from the Planet, which is therefore called the *Parallax* of the annual Orbit. The Word Parallax meaning no more than the *Difference of Places* in which the ſame Object will appear in two different Points of View.

The NODES of a Planet's Orbit are thoſe Points in which the Orbit interſects the Ecliptic. Thus the Equinoctial Points may be called the Node of the Sun's Orbit, with reſpect to the Equinoctial Line; but the Nodes of the Planets are of little Ac-

Account, as they are too ſlow to have a ſenſible Motion in the Space of a few Years; and the Obliquity of their Orbits, or their Inclinations to the Plane of the Ecliptic, are too ſmall to be regarded in the Uſe of the Globes: But it is far otherwiſe with reſpect to the Nodes and Orbit of the Moon; the latter of which makes an Angle of no leſs than 5° 18′ with the Ecliptic, and the Lunar Nodes have too ſenſible a Motion not to be regarded even in the Uſe of the Globes, and therefore a Table is provided in the *Ephemeris* to aſcertain the Place of the Node for every fifth Day of the Month throughout the Year. This gives Occaſion for the Node and Orbit of the Moon to be conſtantly rectified on the Surface of the Celeſtial Globe.

As we ſee not the true and real Motion of the Planets from the Earth, but only their apparent ones, the Direction of thoſe Motions will be often variable; for ſometimes they will appear to be *direct* in Motion, ſometimes *retrograde*, or to move from Eaſt to Weſt; and between theſe two contrary Directions, they will appear to have no Motion for ſome Time, or to be *ſtationary* in the Heavens: Therefore, in the *Ephemeris*, among the Geocentric Places of the Planets, you will ſee the Letter D at the Place where the Planet begins to appear *direct* in Motion; and againſt the Place where it begins to appear *retrograde* there is this Character ℞.

All that we have hitherto ſaid concerning the Places, Nodes, *&c.* of the Planets, are on the Left-hand Page of the *Ephemeris*: On the Right-hand Page are contained, the various Aſpects of the Planets, with reſpect to the Moon and to each other, as they are ſeen from the Earth. Theſe Aſpects they denote by different Symbols; they uſe the Symbol of a *Triangle* △ for the Aſpect they call the *Trine*, that is, when the Planets are a *third Part* of the Ecliptic diſtant from one another, *viz.* four Signs: If they are but three Signs apart, that Aſpect is called *Quartile*, denoted by □: If but two ſigns from each other, it is called a *Sextile*, and is ſhewn by this Mark *: If they are in Conjuction, it is ſhewn by ☌, and if in Oppoſition by ☍; and the Number placed by the Symbol, ſhews the Hour after Noon, when that Aſpect happens. But theſe Aſpects are of little Moment, therefore ſhall ſay no more about them here.

The Figure of the Earth being nearly Globular, a Perſon who walks directly North or South, as his Eye is always the Pole of the Horizon, that horizontal Circle in the Heavens muſt ever move through the ſame Space, or deſcribe the ſame Arch on the Meridian in the Heavens, as he deſcribes or walks through on the Meridian of the Earth:

that is, if he walk through one Degree of the Terreſtrial Meridian Northward, then will his Horizon deſcend one Degree on the Northern Part of the Meridian in the Heavens, and aſcend one Degree on the Southern Part, and ſo for any other Space or Number of Degrees. Therefore if an Inhabitant of the Equator, who views the Poles of the World in the Horizon itſelf, were to ſet out on a Journey directly Northward, when he had travelled over one Degree he would obſerve the North Pole of the World to be elevated juſt one Degree above his Horizon; when he had proceeded over the Space of ten Degrees, as his Horizon was depreſſed ſo many Degrees below the Pole, ſo the Pole muſt of Courſe appear elevated ten Degrees above the Horizon, and ſo much will the South Pole be depreſſed: From whence it appears, that the Elevation of the Pole above the Horizon of any Inhabitant is always equal to his Diſtance from the Equator, in Degrees of the Terreſtrial Meridian: And therefore it is evident, that *the Elevation of the Pole is always equal to the Latitude of the Place:* and this is a fundamental Theorem for the Rectification of both the Globes.

It has been found, by frequent Menſurations, that, in order to raiſe or depreſs the Pole one Degree, a Perſon muſt paſs over the Space of 69 $\frac{1}{2}$ Miles directly North,

or

or South, which, therefore, is the *Engliſh* Meaſure of one Degree of a Terreſtrial Meridian.

Having now premiſed every Thing that ſeems to be neceſſary for the due Underſtanding the Uſe of the Globes, we proceed to the Solution of ſuch Problems in Aſtronomy, Geography, Navigation, Dialing, *&c.* as will afford a rational and inſtructive Amuſement to the young Student in thoſe Sciences, and to Ladies and Gentlemen in general.

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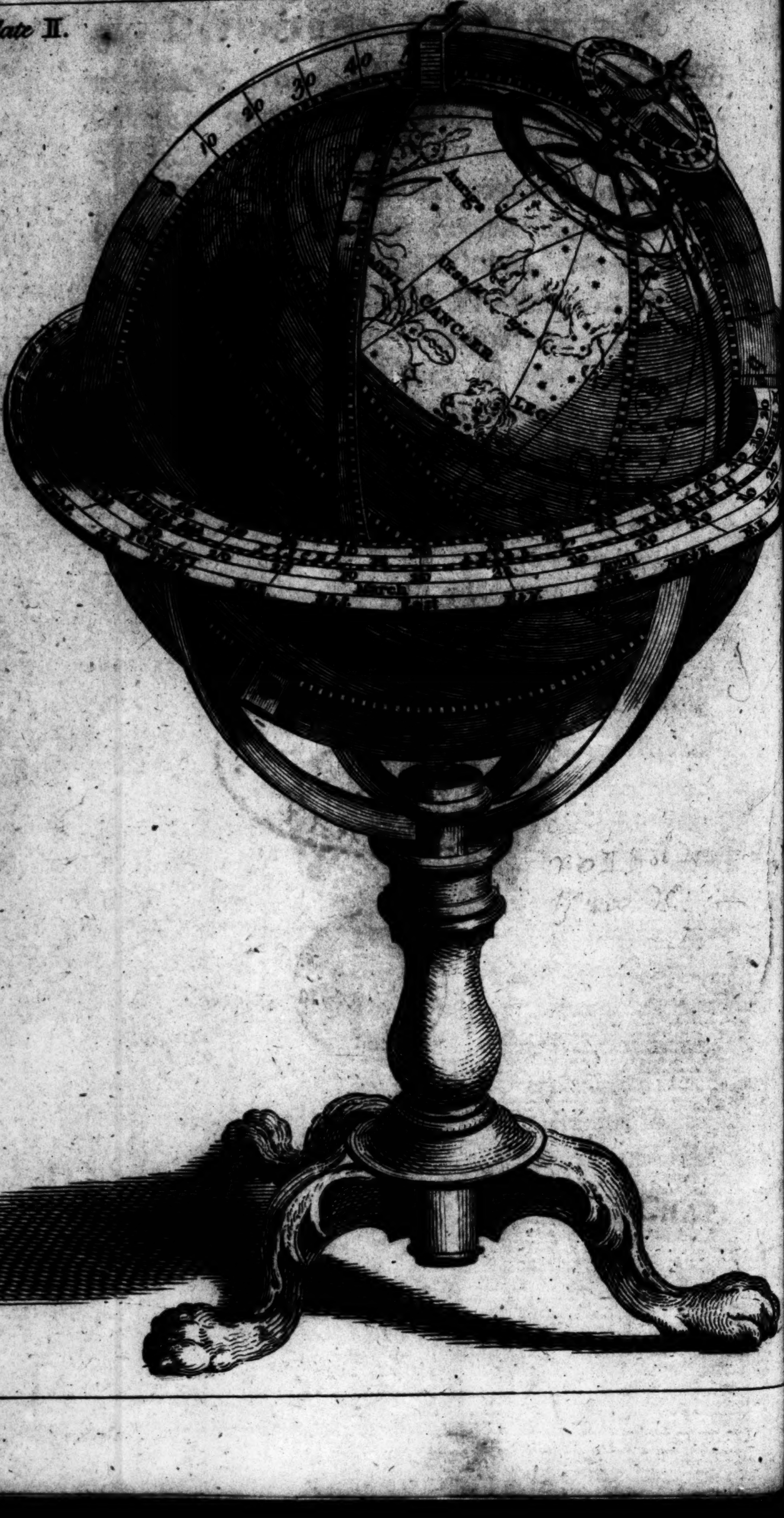
The CELESTIAL GLOBE.

Plate II.



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CHAP. IV.

The Uſe of the CELESTIAL GLOBE *in the* SOLUTION *of* PROBLEMS *relative to the* SUN.

Problem I.

TO *find the* SUN'S PLACE *in the* Ecliptic *for any given Day.*

For this Purpoſe, there are, on the broad Frame of the Horizon, two Calendars of Months and Days, placed by the Ecliptic, divided into its twelve Signs and Degrees. In one Calendar, which is now principally in Uſe, (and call'd the *New Stile)* the Beginning of the 21ſt of *March* nearly anſwers to the Beginning of the Ecliptic, or firſt Point of *Aries*; but in the Calendar of the *Old Stile* the 10th of *March* anſwers to the ſame Point. In either Calendar, therefore, find the given Day of the Month, and, againſt it, obſerve the correſponding Part of the Ecliptic, and that is the Sun's Place for that Day. Thus, for Example, againſt

May 11th you find the 21ſt Degree of *Taurus* for the Place of the Sun in the Ecliptic at that Time.

Prob. II. *To* RECTIFY *the Globe for any particular Place, as* LONDON.

To *rectify* the Globe implies ſeveral particular Things to be done, as (1) Elevate the North Pole above the Horizon ſo many Degrees as is equal to the Latitude of the Place. (2) Find the Sun's Place in the Ecliptic on the Surface of the Globe, and bring it to the brazen Meridian. (3) The Sun's Place being under the Meridian, ſet the Index of the Hour Circle to the upper XII. (4) Set the Meridian of the Globe N. and S. by the Compaſs, or Magnetical Needle, as directed in the Definition thereof. Theſe Things being done, the Globe is *rectified*, or put into a Poſition ſimilar to the concave Surface of the Heavens for the Latitude of ~~*London*.~~ the place.

Prob. III. *To find the Sun's* DECLINATION *for any given Day in the Year.*

Find the Sun's Place in the Ecliptic, and bring it to the Meridian; and the Degree of the Meridian immediately over it is the *Declination* ſought. For Example: On *May* 11th the Sun's Place is in the 21ſt Degree of *Taurus*; this, being brought to the Meridian, will ſhew the Sun's Declination immediately over it to be 18 Degrees.

Prob.

Prob. IV. *To find the* SUN'S RIGHT ASCENTION.

Bring the Sun's Place to the Meridian, and ſee what Point of the Equinoctial is interſected by the Meridian; which, for the 11th of *May*, will be found to be the 47° 40′ for the *Right Aſcenſion* required for that Day.

Prob. V. *To find the* SUN'S AMPLITUDE.

Bring the Sun's Place to the eaſtern Part of the Horizon, and the Arch of the Horizon betwixt it and the eaſtern Point is the Amplitude *Ortive*, North or South: Then turn the Globe about till the Sun's Place is in the weſtern Horizon, then will its occaſive Amplitude be equal to the *Ortive*, and of the ſame Denomination. Thus, on the 11th of *May*, the Sun will riſe with 30° of North Amplitude, and ſet as far from the weſtern Point of the Horizon to the North.

Prob. VI. *To find the* TIME *when the* SUN RISES, *or* SETS, *on any given Day.*

Rectify the Globe for the given Day, then turn the Globe till the Sun's Place touches the eaſtern Part of the Horizon, and the Index of the Horary Circle will ſhew the Time of its riſing. After that turn the Globe about till the Sun's Place comes into the weſtern Semi-circle of the Horizon, and the Index will ſhew the Time of its ſetting for the given Day. Thus, on the 11th of *May*, the

Sun will be ſeen to riſe about a Quarter after ~~before~~ IV. and ſet the ſame Time before VIII.

Prob. VII. *To find the* LENGTH *of any given* DAY *or* NIGHT.

This is immediately deduced from the foregoing Problem; for ſince the Time between riſing to the Meridian, and deſcending from thence to the Horizon, muſt be equal, therefore twice the Hour of ſetting will be the Length of the Day. Thus, on *May* 11, the Sun ſets at VII^h 45′, the double of which Number is XV^h 30′, the Length of the Day; the Length of the Night muſt then be of Courſe VIII^h 30′. Thus the Length of the longeſt and ſhorteſt Days may be found on the Globe, as alſo the greateſt Amplitudes, Declinations, *&c.* and, by a bare Inſpection of the Globe, it will appear, that the longeſt Summer Day is equal to the longeſt Night in Winter, and, *Vice Verſa*, in regard to the Nights.

Prob. IX. *To find the* SUN's *Oblique* ASCENSION.

Find the Place of the Sun in the Ecliptic, and bring it to the eaſtern Horizon: then obſerve the Degree of the Equinoctial in its Interſection with the Horizon, which for the 11th of *May*, you will find to be 21° 40′.

Prob. X. *To find the Aſcenſional Difference, or the Time the* SUN *riſes before or after* SIX.

From the right Aſcenſion (found by Prob. IV.) ſubtract the oblique Aſcenſion, found by the laſt, and the Remainder is the Aſcenſional Difference in Degrees.

		°	′
Thus for the 11th of *May*.	The Right Aſcenſion is	47	40
	Oblique Aſcenſion	21	40
	Aſcenſional Difference	26	00

Prob. XI. *To Convert the* DEGREES, *Minutes, and Seconds, of right* ASCENSION *in the* EQUINOCTIAL, *into* HOURS, *Seconds, and Minutes of* TIME.

This Problem, very uſeful in Aſtronomy, is moſt readily ſolv'd by the following Table:

TABLE

A TABLE.

By which the Longitude *expreſt in* Degrees, Minutes, *and* Seconds, *&c. may be reduced to* Hours, Minutes, *and* Seconds.

Deg.	H.	M.	Deg.	H.	M.	Degrees.	Hours.	
Min.	M.	S.	Min.	M.	S.			
Sec.	S.	T.	Sec.	S.	T.			
1	0	4	31	2	4	70	4	40
2	0	8	32	2	8	80	5	20
3	0	12	33	2	12	90	6	0
4	0	16	34	2	16	100	6	40
5	0	20	35	2	20	110	7	20
6	0	24	36	2	24	120	8	0
7	0	28	37	2	28	130	8	40
8	0	32	38	2	32	140	9	20
9	0	36	39	2	36	150	10	0
10	0	40	40	2	40	160	10	40
11	0	44	41	2	44	170	11	20
12	0	48	42	2	48	180	12	0
13	0	52	43	2	52	190	12	40
14	0	56	44	2	56	200	13	20
15	1	0	45	3	0	210	14	0
16	1	4	46	3	4	220	14	40
17	1	8	47	3	8	230	15	20
18	1	12	48	3	12	240	16	0
19	1	16	49	3	16	250	16	40
20	1	20	50	3	20	260	17	20
21	1	24	51	3	24	270	18	0
22	1	28	52	3	28	280	18	40
23	1	32	53	3	32	290	19	20
24	1	36	54	3	36	300	20	0
25	1	40	55	3	40	310	20	40
26	1	44	56	3	44	320	21	20
27	1	48	57	3	48	330	22	0
28	1	52	58	3	52	340	22	40
29	1	56	59	3	56	350	23	20
30	2	0	60	4	0	360	24	0

EXAMPLE.

EXAMPLE.

In what Time will 49° 37′ *and* 13″ *of the Equinoctial paſs under the Meridian?*

Againſt	49°	0′	0″—	3^{h}	16′	0″	0‴
		37	0—		2	28	0
			13—			0	52
Anſwer	49	37	13	3	18	28	52

Thus the Aſcenſional Difference, being juſt 26°, anſwers to 1^{h} 44′, which is an Hour and $\frac{3}{4}$ before ſix, agreeable to Problem VI.

Prob. XI. *To convert* TIME *into* MOTION, *or to tell what Number of Degrees, Minutes, and Seconds, paſs under the Meridian in a given Time.*

The Solution of this Problem is likewiſe moſt eaſy by a Table, which we have therefore here inſerted:

EXAMPLE.

Suppoſe it be required to know what Number of Degrees, Minutes, and Seconds, of the Equinoctial, paſs under the Meridian in 3^{h} 18′ 28″ 52‴, the Quantities of Motion taken out of the Second Column, anſwering to the ſeveral Parts of Time in the firſt Column, being placed appoſitely, and added together as before, will give the Anſwer, 49^{h} 37′ 13″.

A TABLE.

By which the Longitude *expreſt in* Hours, Minutes, *and* Seconds, *&c. may be reduced to* Degrees, Minutes, *and* Seconds, *&c.*

Hours	Degrees.	Min.	Deg.	Min.	Min.	Deg.	Min.
		Sec.	Min.	Sec.	Sec.	Min.	Sec.
		Th.	Sec.	Th.	Th.	Sec.	Th.
1	15	1	0	15	31	7	45
2	30	2	0	30	32	8	0
3	45	3	0	45	33	8	15
4	60	4	1	0	34	8	30
5	75	5	1	15	35	8	45
6	90	6	1	30	36	9	0
7	105	7	1	45	37	9	15
8	120	8	2	0	38	9	30
9	135	9	2	15	39	9	45
10	150	10	2	30	40	10	0
11	165	11	2	45	41	10	15
12	180	12	3	0	42	10	30
13	195	13	3	15	43	10	45
14	210	14	3	30	44	11	0
15	225	15	3	45	45	11	15
16	240	16	4	0	46	11	30
17	255	17	4	15	47	11	45
18	270	18	4	30	48	12	0
19	285	19	4	45	49	12	15
20	300	20	5	0	50	12	30
21	315	21	5	15	51	12	45
22	330	22	5	30	52	13	0
23	345	23	5	45	53	13	15
24	360	24	6	0	54	13	30
		25	6	15	55	13	45
		26	6	30	56	14	0
		27	6	45	57	14	15
		28	7	0	58	14	30
		29	7	15	59	14	45
		30	7	30	60	15	0

Thus,

	h	′	″	‴		°	′	″
Thus, against	3	0	0	0	You find	45	0	0
		18	0	0		4	30	0
			28	0			7	0
				52				13
	3	18	28	52	Sum	49	37	13

Prob. XII. *To find the Beginning and End of the Crepuſculum, or* TWILIGHT, *for any given Day of the Year.*

In the Solution of this and the following Problem, the Quadrant of Altitude will be neceſſary, which, therefore, muſt now be ſcrewed on to the Zenith Point, or ſo that the Fiducial Edge of the Nut may cut 51° 30″ of the Meridian, which is the Zenith of *London*, the Globe being ſuppoſed rectified for this Metropolis.

It is collected from many Obſervations that have been made by Aſtronomers, that the Sun, after its Deſcent below the Horizon, has its Rays refracted through, and enlightening the Atmoſphere near the Earth, till his Depreſſion be equal to about 18°, at the End of which Time the Atmoſphere becomes wholly Dark, at leaſt what we call dark Night then begins; and the Time from ſuch ſetting, 'till his Depreſſion be 18° below the Horizon, is called the *Crepuſculum*, or *Twilight*. But when the Sun is 18° below the Horizon, at any Time,

the

the Place in the Ecliptic Diametrically oppoſite to the Sun, is, of Courſe, 18° above the Horizon: And therefore let us ſuppoſe the Sun in the firſt Degree of *Taurus*, which, by the Calendar, you will ſee is on the 21ſt of *April*. The Point of the Ecliptic oppoſite to this is the beginning of *Scorpio*: Therefore, when the Sun, in the firſt Scruple of *Taurus*, is below the Horizon in the Weſtern Hemiſphere, the beginning of *Scorpio* will be 18° above the Eaſtern Horizon: Conſequently, if the Quadrant of Altitude, and the Globe be ſo moved together 'till the beginning of *Scorpio* coincides with the 18° of the Quadrant, then will the Index Point to the Time when the *Twilight* ends on the 21ſt of *April*, which will be about 25′ after IX, and the Sun ſets that Day about VII, as will be found by *Problem* VI. Therefore the Length of the Morning and Evening Twilight, will, on that Day, be near 2^h 30′.

Prob. XIII. *To find the* ALTITUDE *of the* SUN *on any given* HOUR *of the* DAY, *and Latitude of the Place.*

Find the Sun's Place in the Ecliptic, bring it to the Meridian, and ſet the Hour Index to XII: Then move the Globe about 'till the Index points to the given Hour; and the Quadrant of Altitude being ſcrewed to the Zenith, bring it to lie over the Sun's

Place, and the Number of Degrees upon the Quadrant, contained between the Sun's Place and the Horizon, will be the Altitude required. Thus, for Example; on the 11th of *May*, at IX in the Morning, the Sun's Altitude will be found near 42 Degrees.

N. B. If the Place of the Sun be brought to the Meridian, it is then ſaid to *Culminate*; and its *Meridian Altitude* for that, or any other Day, while it is in the ſix Northern Signs, will be evidently equal to its Declination added to the Elevation of the Equator, or Complement of the Latitude. But, while the Sun is in the ſix Winter Signs, the Sun's Declination, deducted from the *Co-latitude*, will give his *Meridian Altitude*.

Prob. XIV. *To find the* SUN'S AZIMUTH *for any given* HOUR *of the* DAY, *and Latitude of the Place.*

Rectify the Globe, and proceed as directed in the laſt Problem: then the Angle, or Arch of the Horizon contained between the Meridian and Quadrant of Altitude, will be the Azimuth of the Sun at the North or South Part of the Horizon, at the given Hour of the Day.

Prob. XV. *To find the* SUN'S ALTITUDE, *when it ſhines, by the* GLOBE *only.*

Set the Frame of the Globe truly level, and turn the North Pole towards the Sun; then gently move the Frame, and the Meridian, up and down in the Notches of the Horizon, 'till the Axis caſts no Shadow: Then the Arch of the Meridian, contained between the Arch of the Horizon, is the Sun's Altitude.

Prob. XVI. *To find the* HOUR *of the* DAY *and the Sun's* AZIMUTH, *having the Latitude of the Place, the Place of the Sun, and its Altitude known by Obſervation.*

Rectify the Globe for the Latitude and Place of the Sun, then move the Globe and Quadrant of Altitude ſo together, that the Sun's Place may cut the given Degree of Altitude on the Quadrant: Then the Index will ſhew the Hour, and the Quadrant will cut the Azimuth in the Horizon. Thus, at *London*, on the 11th of *May*, ſuppoſing the Sun's Altitude be obſerved in the Forenoon to be 42°, then will the Index point to the Hour of IX, and the Sun's Azimuth is about 63° from the South.

N. B. The Sun's ~~Azimuth~~ altitude is eaſily taken by any Quadrant having Sights and a Plumb-line, for, by holding the Quadrant toward the Sun, ſo that its Rays, paſſing through a ſmall Hole in one Sight, may fall exactly on the correſpondent Hole on the other, then will the Plumb-line cut the Degrees on the Limb of the Quadrant equal to the Height of the Sun. But the beſt and moſt accurate Method of taking the Sun's Altitude, is by a *Hadley*'s Quadrant with an ARTIFICIAL HORIZON, with a Compaſs and Azimuth Circle on a proper Foot, or Stand.

Prob. XVII. *To find the* HOUR *of the* DAY, *when the* SUN *ſhines, for any given Latitude and Day of the Month.*

Place the Frame of the Globe level, and the Meridian due North and South by the Needle; then Rectify the Globe to the Latitude, and fix a Pin or Needle perpendicular to the Surface of the Globe, in the Place of the Sun, which bring to the Meridian, and fix the Hour Index to XII: then turn the Globe about till the Pin caſt no ſhadow, for it will then be exactly under the Sun, and the Index will ſhew the Hour of the Day.

Prob. XVIII. *To find the* ALTITUDE *of the Sun and Hour of the Day, from the* LATITUDE, *Place of the* SUN, *and his* AZIMUTH *given.*

Rectify the Globe for the Latitude, Place of the Sun, &c. then place the Quadrant of Altitude to the given Azimuth in the Horizon, and move the Globe about till the Sun's Place comes upon the Edge of the

Quadrant, which will then ſhew its Altitude, and the Index will point to the Hour. Thus, ſuppoſe, at *London* on the 11th of *May*, I obſerve the Azimuth of the Sun in the Forenoon to be 63° from the South, then having placed the Quadrant of Altitude to that Degree of the Horizon, and brought the Sun's Place, or 11 ~~20th~~ Degree of Taurus ~~Gemini,~~ to the Edge of it, it will cut 42 of the Quadrant for the Sun's Altitude, and the Index will point to IX o'Clock.

Prob. XIX. *To find the* LATITUDE *of the* PLACE, *from the given Declination and Meridian* ALTITUDE *of the* SUN.

Mark the Point of Declination upon the Meridian, whether North or South, then ſlide the Meridian up or down in the Notches till the Point of Declination be ſo far diſtant from the Horizon, as is equal to the given Meridian Altitude: then will the Axis of the Earth, or Pole of the World have its proper Height above the Horizon, and ſhew the true Latitude of the Place. The Reaſon of this Problem is very evident, from the Note of Problem XIII.

Prob. XX. *To find the* ANGLE *which the* ECLIPTIC *makes with the* HORIZON, *for any* HOUR *of a given* DAY *and* LATITUDE *of the Place.*

Rectify the Globe for the Latitude, Sun's Place, and given Hour; then lay the Quadrant of Altitude over the Pole of the Ecliptic, and the Arch of the Quadrant, contained between that Pole and the Zenith, will ſhew the Number of Degrees in the *Altitude* of the Ecliptic, or *Nonageſimal* Degree; Thus, on the 11th of *May* at IX in the Morning, the Pole of the *Ecliptic* will be diſtant from the *Zenith* 44° 30′, which is equal to the Elevation of the Ecliptic above the Horizon at that Time.

Prob. XXI. *To find the* POSITION, *or* AZIMUTH *of the* NONAGESIMAL DEGREE *of the Ecliptic, for any given* LATITUDE, *and* TIME *of the* DAY.

Let every Thing be done as directed in the laſt Problem; then obſerve the Number of Degrees in the Arch of the Horizon, intercepted between the North Point and the Quadrant of Altitude, lying over the Pole of the Ecliptic; for that will be the Azimuth of the *Nonageſimal* Degree from the South Point of the Horizon. Thus, for the 11th of *May*, in the Latitude of *London*, at IX in the Morning, it will be about 25 Degrees.

Prob. XXII. *To find the* POINT *of the* ECLIPTIC, *which is the* NONAGESIMAL

DEGREE, *for any given* TIME *of the* DAY, *and* LATITUDE *of the Place*.

Having found the Azimuth of the *Nonageſimal* Degree by the laſt Problem, bring the Quadrant of Altitude to cut the South Part of the Horizon in the ſame Number of Degrees, while the Hour-hand points at the given Time; then will the Edge of the Quadrant interſect the Ecliptic in the *Nonageſimal* Degree required, which for the 11th of *May*, at IX in the Morning, at *London*, will be 22° 30′ of *Taurus*.

N. B. In the ſix aſcending Signs, the *Nonageſimal* Degree is always to the Eaſt of the Meridian; but in the ſix deſcending Signs, it is to the Weſtward of it. Note alſo, the Point called *Medium Cœli*, or *Mid-Heaven*, is that Degree of the Ecliptic which *culminates*, or is in the Meridian; and therefore is always known by Inſpection, which in this Example is 29° of *Aries*.

Prob. XXIII. *To find the* DEPRESSION *of the* SUN *below the* HORIZON, *and the* AZIMUTH *at any* HOUR *in the* NIGHT, *for the* GIVEN TIME *and* LATITUDE *of the Place*.

Having rectified the Globe for the Latitude, Sun's Place, and Hour of the Night; take a Point in the Ecliptic exactly oppoſite to the Sun's given Place, and then find the Sun's Altitude and Azimuth for that Point, as directed in Prob. XIII. and XIV. and theſe will be the Depreſſion and the *Azimuth* required. Thus, for the 11th of *May*, the Sun being in the 20° of *Taurus*, and turning the Globe about till the Index points at IX at Night, you will obſerve the oppoſite Point of the Ecliptic, which is the 20° of *Scorpio*, juſt as far above the Southern Horizon as the Sun's Place is depreſſed below the Northern Part: Then bringing the Quadrant of Altitude to lie over that Degree, you will obſerve its Altitude on the Edge of the Quadrant to be 19° 30′, and its Azimuth 17° from the South; and ſuch is the Depreſſion of the Sun, and its Azimuth from the North, at the given Time.

CHAP. V.

The USE *of the Celeſtial* GLOBE *in the* SOLUTION *of* PROBLEMS *concerning the* MOON.

THE he foregoing Problems are ſuch as relate to the Sun, whoſe Path being conſtantly the ſame in the Heavens, and the Motion of the Nodes of his Orbit not ſenſible in a few Years, therefore a Solution of Problems relative to this Luminary are of the moſt ſimple Kind, and admit of no Variation in a long Courſe of Time: But it is far otherwiſe with Reſpect to the Moon, whoſe Orbit conſtantly varies its Poſition, and the Place of its Node always changing; we do not here ſpeak of its variable Inclination to the Ecliptic, as being too nice an Affair in the Uſe of the Globe.

Again; the Motion of the Moon being very irregular and variable in every Part of its Orbit, this, together with the Motion of the Orbit itſelf, makes it impoſſible to aſcertain her Place by any conſtant Calendar, ſuch as we uſe for the Sun; but her Place muſt be previouſly calculated for every Day in every Month, and that for every particular Year: Such Calculations diſpoſed in proper Tables, make what is called an *Ephemeris* of the Moon's Motion: but, even in this *Ephemeris*, her Place is only ſhewn at the Beginning of each Day, or XII o'Clock at Noon. If her Place be required for any other Time of the Day, that muſt be found by conſidering what is the Quantity of her diurnal Motion, or the Space in the Ecliptic ſhe paſſes through for that Day. For this Purpoſe, there is likewiſe a proper Table inſerted in the ſame *Ephemeris*, to be applied to on theſe Occaſions. This Table is placed immediately before *January* in *Parker*'s *Ephemeris*. And whereas there have been many Contrivances for repreſenting the variable Path, or Orbit of the Moon, over the Surface of the Celeſtial Globe, and ſome of them both troubleſome and expenſive, I ſhall here deſcribe the

Method which I have always uſed myſelf, and think to be the moſt natural, eaſy, and demonſtrable of any, which is, by tying faſt a ſilken Line over the Surface of the Globe, exactly on the Ecliptic, which may be removed towards the North, or South, juſt equal to the Latitude of the Lunar Orbit in the Heavens, and the Points of Interſection with the Ecliptic will be ſuch, as the Table in the *Ephemeris* aſſigns for every Day in the Year.

That Point of Interſection, or NODE of the Lunar Orbit, in which the Moon aſcends from the Southern to the Northern Part, is called the *Aſcending Node*, or, (according to the aſtrological Cant) the *Dragon's Head*, and is diſtinguiſhed by this Character ☊; and the other Node, or *Dragon's Tail*, is repreſented by the ſame Character inverted, thus ☋: But this laſt is not found in the *Ephemeris*, as not being neceſſary; for the Place of one Node being given, the Place of the other is known, as being diametrically oppoſite to it.

Becauſe an *Ephemeris* is not in every one's Hands, and yet is very neceſſary for the Uſe of the Celeſtial Globe in its full Extent, it will be proper here to inſert that Part of it which contains the Calculations in the Month of *May*, of the preſent Year 1762, and to demonſtrate the Neceſſity of its Uſe, in a Solution of the following Lunar Problems.

May

May 1762.

The Planets daily Motions Geocentrick.												☊	♉
The Planets Lat. and Place of ☽'s ☊ to every 6th Day.	1	2S.	16	1 S.	5	1N	17	0S.	19	2S.	46	11	34
	7	2	16	1	5	1	1	0	5	2	22	11	34
	13	2	17	1	6	0	45	0N	10	1	39	11	34
	19	2	18	1	6	0	30	0	25	0	42	11	32
	25	2	19	1	7	0	10	0	39	0N	21	11	26

M D	☉	♉	☽	♌	Moon's Lat. Bor.		♄	♈	♃	♈	♂	♎ ℞	♀	♉	☿	♈	Sun's Dec. North.	
1	11	1	14	36	5	17	17	29	22	56	18	51	19	39	17	28	15	10
☉	11	59	28	50	5	3	17	36	23	10	18	33	20	53	18	59	15	28
3	12	57	13 ♍	1	4	31	17	44	23	24	18	16	22	7	20	32	15	45
4	13	55	27	8	3	42	17	51	23	38	17	59	23	21	22	7	16	3
5	14	53	11 ♎	8	2	41	17	58	23	52	17	43	24	35	23	44	16	20
6	15	51	24	57	1	31	18	5	24	6	17	28	25	49	25	23	16	37
7	16	49	8 ♏	34	0	17	18	12	24	20	17	13	27	3	27	3	16	53
8	17	47	21	54	0 A.	57	18	19	24	34	16	59	28	17	28	46	17	10
☉	18	45	4 ♐	58	2	6	18	26	24	48	16	46	29	30	0 ♉	31	17	26
10	19	43	17	45	3	7	18	33	25	2	16	33	0 ♊	44	2	18	17	42
11	20	40	0 ♑	17	3	58	18	40	25	15	16	21	1	58	4	7	17	57
12	21	38	12	34	4	37	18	46	25	29	16	10	3	12	5	57	18	12
13	22	36	24	40	5	3	18	53	25	43	16	0	4	25	7	49	18	27
14	23	34	6 ♒	38	5	15	19	0	25	57	15	51	5	39	9	43	18	42
15	24	32	18	32	5	14	19	6	26	10	15	43	6	53	11	40	18	56
☉	25	29	0 ♓	26	4	59	19	31	26	24	15	35	8	6	13	39	19	10
17	26	27	12	26	4	31	19	20	26	37	15	28	9	20	15	40	19	24
18	27	25	24	35	3	51	19	26	26	51	15	22	10	34	17	42	19	37
19	28	22	6 ♈	58	2	59	19	33	27	4	15	17	11	47	19	46	19	50
20	29	20	19	38	1	58	19	39	27	17	15	12	13	1	21	52	20	3
21	♊	18	2 ♉	38	0	49	19	46	27	31	15	8	14	14	23	59	20	15
22	1	15	15	59	0 B.	25	19	52	27	44	15	5	15	28	26	8	20	27
☉	2	13	29	41	1	39	19	59	27	57	15	3	16	4	28	18	20	39
24	3	10	13 ♊	42	2	48	20	5	28	10	15	2	17	55	0 ♊	28	20	50
25	4	8	27	58	3	49	20	11	28	23	15	2	19	8	2	39	21	1
26	5	5	12 ♋	24	4	35	20	17	28	36	15 D.	3	20	22	4	51	21	11
27	6	3	26	53	5	4	20	23	28	49	15	4	21	35	7	2	21	21
28	7	0	11 ♌	20	5	14	20	29	29	2	15	6	22	49	9	14	21	31
29	7	58	25	41	5	4	20	35	29	14	15	8	14	2	11	26	21	41
☉	8	55	9 ♍	52	4	34	20	40	29	27	15	11	25	15	13	37	21	50
31	9	53	23	52	3	51	20	46	29	39	15	15	26	29	15	48	31	58

	The Heliocentrick Motions.												May 1762.						
Days	♄	♈	♃	♈	♂	♏	⊖	♏	♀	♊	☿	♒	Day-lig. B.	&	E.	Sun Ri.	Set	Clock too ſlow	
1	15	1	19	19	2	46	11	1	1	48	4	52	2	6	10	4 40	8	3	8
7	15	14	19	52	5	41	16	49	11	30	26	24	1	44	11	4 29	8	3	45
13	15	26	20	25	8	38	22	36	21	8	21	♓ 49	1	19	11	4 20	8	4	1
19	15	39	20	58	11	36	28	22	0	♋ 50	22	♈ 17	0	48	12	4 12	8	3	58
25	15	51	21	31	14	36	4	♐ 8	10	33	27	♉ 48	No Nig			4 4	8	3	33

	H. Wat. Lon. B.				The Lunar Aſpects.						The Mutual Aſpects.
	Morn.		Aftern.		☉	♄	♃	♂	♀	☿	
1	7	48	8	23		△ 5	△ 14	* 7	□ 9	△ 5	☌ ♄ ☿ ☽ Perig.
☉	8	59	9	35							☍ ♂ ☿
3	10	7	10	40	△ 0				△ 17		
4	11	11	11	42							☍ ♄ ♂
5			0	9		☍ 13	☍ 23	☌ 11			☌ ♃ ☿
6	0	36	1	1						☍ 1	
7	1	26	1	51	☍ 16						
8	2	16	2	37					☍ 13		
☉	2	58	3	15				* 22			
10	3	32	3	48		△ 2	△ 15				
11	4	5	4	26				□ 9		△ 8	
12	4	46	5	7	△ 19	□ 15					
13	5	27	5	51			□ 2		△ 21		
14	6	15	6	40				△ 19		□ 6	☽ Apog.
15	7	5	7	31	□ 13	* 2	* 17				
☉	7	58	8	24					□ 16		
17	8	50	9	19						* 6	
18	9	48	10	14	* 6						
19	10	40	11	7				☍ 17	* 10		
20	11	34				☌ 0	☌ 14				
21	0	1	0	27							
22	0	54	1	20						☌ 21	
☉	1	46	2	12	☌ 5						
24	2	36	3	0		* 12		△ 2	☌ 8		
25	3	20	3	41			* 1				
26	4	2	4	23		□ 14		□ 5			☌ ☉ ☿ * ♄ ♀
27	4	47	5	10	* 14		□ 4			* 16	
28	5	36	6	2		△ 16		* 7	* 20		☽ Perig.
29	6	31	7	0	□ 22		△ 6				
☉	7	29	7	58						□ 7	
31	8	29	9	0					□ 5		△ ♂ ☿

Prob. XXIV. *To find the* NODES *of the* MOON'S ORBIT *for any given* TIME.

On the firſt Page, *May* 1762, in the Table of *Geocentric* Motions, is a ſmall Table, on the Top, containing the Motion of the Planets for every ſixth Day; but in the laſt Column of this Table, towards the Right-hand, are the Numbers which ſhew the Sign, Degree, and Minutes of the Place of the Node. Thus, for Inſtance, on the 11th of *May*, 1762, the Place of the aſcending Node will be found in ♉ 11° 34′; and, therefore, the deſcending Node will be in the ſame Degree and Minute of the oppoſite Sign *Scorpio* ♏.

N. B. You will find, by this Table, that the Motion of the Lunar Nodes is ſo very ſlow as to alter but a few Minutes in a Month, it making one Revolution through the Ecliptic in about 19 Years.

Prob. XXV. *To aſſign the* ORBIT *of the* MOON *its proper* POSITION *in the Heavens for any given* TIME.

Having found the Node by the foregoing Problems, reckon from thence 90° each Way in the Ecliptic, where you muſt begin to elevate, or remove the Silken-Thread, or Line, (now lying on the Ecliptic) towards each of its Poles, keeping it, without any Motion, in the Points of the Nodes, by a gradual removing

moving the Moon's Orbit from the Ecliptic you will ſtop at her utmoſt Latitude, which is 5 ¼ Degrees; which points on either Side of the Ecliptic, are eaſily determined by the Parallels of Latitude which paſs through every Degree, to the extent of the *Zodiac*, on either Side the Ecliptic in all Mr. *Senex*'s Globes. The Silk-line, in this Poſition, will duely repreſent the Lunar Orbit in the Heavens for that Day.

Prob. XXVI. *To find the Moon's* DIURNAL MOTION, *in the* ECLIPTIC, *for any given* DAY.

Find her Place for the given Day at Noon in the ſecond Column of daily Geocentric Motions, and ſubtract from it her Place on the preceding Day at Noon, and the Difference will be the Space ſhe has deſcribed for that Day, and is the Quantity of the Diurnal Motion ſought. For Example, let her Diurnal Motion be required for the 11th of *May*, 1762.

On the 11th of *May* her Place is	♑	0°	17′
On the 10th of *May*	♐	17	45
The Diurnal Motion		12	37

Now the Diurnal Motion of the Moon being variable from 11° 46′ when leaſt, to 15° 16′ when greateſt, there is a proper Table added (as I have ſaid before) at the Beginning of the *Ephemeris*, containing the Diurnal Motions from the leaſt to the greateſt, which differ only by 10′ in 22 different Columns; of Courſe, upon the Top of one of theſe you will obſerve the Diurnal Motion, juſt now found, prettynearly; and the 24 Hours being placed by the Side of the Table, it will be eaſy from thence, to obſerve what Part of the Diurnal Motion of the Moon anſwers to any given Number of Hours. Thus, for the Diurnal Motion above found of 12° 37′, you will find, on the Top of the 6th Column, 12° 36′, and under it, againſt the 9^h, you will find 4° 43′, which is her Motion in the Ecliptic in the Space of 9^h for that Day.

Prob. XXVII. *To find the* MOON'S PLACE *in the Ecliptic for any given* HOUR *of the* DAY.

Look in the ſecond Column of the large Table of the daily Geocentric Motions, and you will find, oppoſite to the given Day of the Month, the Moon's Place in the Ecliptic for that Day at Noon; and, by the foregoing Problem, find the Space ſhe has deſcribed ſince Noon to the given Moment of Time, which, added to the former, will be her Place in the Ecliptic, as required for the preſent Moment; Thus on the 10th of *May* her Place at Noon will be found in 17° 45′

of ♐, and ſince her Motion for that Day is 12° 37′, in nine Hours ſhe will have paſſed over 4° 43′, which added to her Place at Noon, will give 22° 28′ of ♐ for her Place on the 10th of *May* at IX at Night.

Prob. XXVIII. *To find the* Moon's Place *in her* Orbit *for any given* Day *and* Hour.

Having found her Place in the Ecliptic by the preceding Problem, you are to obſerve, that through every Degree of the Ecliptic, perpendicular thereto, are drawn in the Zodiac, *Circles of Latitude:* Then that Circle which paſſes through the Moon's Place in the Ecliptic will interſect the Silken-line, and, thereby, ſhew her true Place in that Artificial Orbit, which may be denoted by a Piece of a Patch, cut in Form of a *Creſcent*, and placed under the ſaid Line, where we ſuppoſe it to remain during the Courſe of theſe Problems, which will all have regard to the 10th of *May* at IX o'Clock at Night.

Prob. XXIX. *To find the* Latitude *of the* Moon *for any given* Day *and* Hour.

Having found her Place in the Ecliptic, and alſo in her Orbit, the Arch of a Circle of Latitude between theſe two Points will be the Quantity of her Latitude ſought, and is eaſily ſeen in Degrees and Parts of a Degree on the *Zodiac* of the Globe. Thus, for the 10th of *May*, 1762, at Noon, her Latitude is 3° 7′, the ſame as you will obſerve in the third Column of Geocentric Motions against the given Day.

N. B. In the Column of Latitudes you will ſee the Letter A, denoting the South Latitude, and the Letter B denoting the North Latitude; and by theſe you will eaſily ſee when the Moon is in either Node, as there ſhe has no Latitude at all.

Prob. XXX. *To find the* MOON'S DECLINATION *for any given* DAY *or* HOUR.

The Place in her Orbit being found, by Problem XXVIII, bring the *Creſcent* to the brazen Meridian: Then the Arch of the Meridian, contained between it and the Equinoctial, will be the Declination ſought, which, in the foregoing Example on the 10th of *May* at Noon, 1762, will be about 25°.

Prob. XXXI. *To find the* MOON'S *greateſt and leaſt* MERIDIAN ALTITUDES *in any given* LATITUDE, *that of* LONDON, *for Example.*

It is evident, this can happen only when the aſcending Node of the Moon is in the vernal Equinox; for then her greateſt Meridian Altitude will be 5° greater than that of the Sun, and therefore about 67°: alſo her leaſt Meridian Altitude will be 5° leſs than that of the Sun, and therefore only 10°: there will therefore be 57° Difference in the Meridian Altitude of the Moon; whereas, that of the Sun is but 47°.

N. B. When the ſame aſcending Node is in the autumnal Equinox, then will her Meridian Altitude differ by only 37°: But this Phænomenon can ſeparately happen but once in the Revolution, or a Node, or once in the Space of nineteen Years: And it will be a pleaſant Entertainment, to place the Silken-line to croſs the Ecliptic in the Equinoctial Points alternately; for then the Reaſon will more evidently appear, why you obſerve the Moon ſometimes within 23° of our Zenith, and at other times not more than 10° above the Horizon, when ſhe is full South.

Prob. XXXII. *To find the Time of the* MOON'S RISING, SOUTHING, *and* SETTING, *for any* LATITUDE *and given* DAY *of the* YEAR.

Firſt, rectify the Globe for the Latitude of the Place, and find the Moon's Place in her Orbit at Noon, for the given Day, which bring to the brazen Meridian, and ſet the Hour Index at XII: Then bring her Place to the Eaſtern Part of the Horizon, and the Index will ſhew the Time of her Semi-diurnal Arch, ſuppoſing the Moon were fixed in her Orbit; but as ſhe is not, the Quantity of her Motion, during the Time of that Semi-diurnal Arch, muſt be found and ſubtracted from her Place at Noon, in order to give her Place in her Orbit pretty nearly at riſing; and the ſame Motion muſt be added to her Place at Noon, in order to give her Place in her Orbit at ſetting. Thus, for Example: on the 10th of *May*, 1762, at *London*, the Moon's Place was found in 18° of *Sagittarius*, which will give the Semi-diurnal Arch about 4^h, in which Time the Motion of the Moon will be about 2°; therefore her Place, at riſing, will be 16° of that Sign, and her Place at ſetting about 20°.

Secondly, find the Sun's Place for the 10th of *May* at Noon, bring it to the Meridian, and ſet the Hour Index to the upper XII: Then turn the Globe about till the 16° of *Sagittarius* coincides with the Eaſtern Part of the Meridian; then will the Index Point to nearly Half an Hour after X at Night, which will be the Time of her riſing. Then bring the 18° of the ſame Sign to the Meridian, and the Index will point to II in the Morning for the Time of her *Southing*. Laſtly, the 20° of *Sagittarius*, being brought to the Weſtern Part of the Horizon, will ſhew the Time of her *ſetting* about a ¼ after V in the Morning.

Prob.

Prob. XXXIII. *To find the* AMPLITUDE, AZIMUTH, ALTITUDE, *&c. &c. of the Moon for any given* DAY, HOUR, *and* LATITUDE *of the* PLACE.

When the Place of the Moon in her Orbit is found for the given Day and Hour, and the Globe rectified for the given Latitude, then the Amplitude, Azimuth, Altitude, *&c.* of the Moon will be found in the ſame Manner as directed for thoſe of the Sun, *viz.* by obſerving the Degrees of the Horizon in which the Moon riſes and ſets in the given Day; and by laying the Quadrant of Altitude (fixed in the Zenith) over the Moon's Place, or *Creſcent*, when in any Poſition above the Horizon, or elſe over the Point of the Moon's Orbit exactly oppoſite to it, when it is depreſſed below it.

Prob. XXXIV. *To explain the Phænomena of the* HARVEST, *or* SHEPHERDS MOON.

What is uſually called the Harveſt Moon is the full Moon that happens when the Sun is near the autumnal Equinox, which every Night ſucceſſively riſes within a very ſhort Time of the Sun's ſetting, by which Means the Hemiſphere becomes almoſt conſtantly enlightened by one Luminary or the other: whence it happens, that the Nights become very lightſome and pleaſant, and, therefore, very advantageous for *Harveſt* People, *Shepherds*,

herds, *Hunters*, *&c.* on which Account it receives thoſe various Appellations.

On the contrary, at the oppoſite Time of the Year, or vernal Equinox, a conſiderable Time elapſes between the ſetting of the Sun and riſing of the full Moon; thereby occaſioning the Nights to be dark even at the Time of a full Moon: The Reaſon of all which will very eaſily appear, by only conſidering the very different Angle which the Ecliptic makes with the Horizon at thoſe two oppoſite Seaſons of the Year: For in the Latitude of *London*, at the Time of the vernal Equinox, when the Sun is ſetting in the Weſtern Part of the Horizon, the Ecliptic then makes an Angle of 62° with the Horizon; but when the Sun is in the autumnal Equinox, and ſetting in the ſame Weſtern Part of the Horizon, the Ecliptic makes an Angle but of 15° with the Horizon: All which is evident by a bare Inſpection of the Globe only.

Again, according to the greater, or leſs Inclination of the Ecliptic to the Horizon, ſo a greater or leſs Degree of Motion of the Globe about its Axis will be neceſſary to cauſe the ſame Arch of the Ecliptic to paſs through the Horizon; and, conſequently, the Time of its Paſſage will be greater, or leſs, in the ſame Proportion: But this will be beſt illuſtrated by an Example.

Therefore, ſuppoſe the Sun in the vernal Equinox, and rectifying the Globe for the Latitude of *London*, and Place of the Sun, bring the *vernal* Equinox, or Sun's Place to the Weſtern Edge of the Horizon, and the Hour Index will point preciſely to VI; at which Time, we will alſo ſuppoſe the Moon to be in the *Autumnal* Equinox, and, conſequently, at Full, and riſing exactly at the Time of Sun-ſet.

But on the following Day, the Sun, being advanced ſcarcely one Degree in the Ecliptic, will ſet again very nearly at the ſame Time as before: But the Moon will, at a mean Rate, in the Space of one Day, paſs over 13° in her Orbit; and therefore, when the Sun ſets in the Evening after the Equinox, the Moon will be below the Horizon, and the Globe muſt be turned about till 13° of *Libra* comes up to the Edge of the Horizon, and then the Index will Point to 7^h 16′, the Time of the Moon's riſing; which is an Hour and ¼ after Sun-ſet for dark Night. The next day following, there will be 2^h and ½, and ſo on ſucceſſively, with an Increaſe of 1^h and ¼ Dark-night each Evening reſpectively, at this Seaſon of the Year; all owing to the very great Angle which the Ecliptic makes with the Horizon at the Time of the Moon's riſing.

On the other Hand, ſuppoſe the Sun in the Autumnal Equinox, or beginning of *Libra*, and the Moon oppoſite to it in the vernal Equinox, then the Globe (Rectified as before) being turned about till the Sun's Place comes to the Weſtern Edge of the Horizon, the Index will point to VI, for the time of his ſetting, and the riſing of the Full-moon on that Equinoctial Day. On the following Day, the Sun will ſet nearly at the ſame Time; but the Moon being advanced (in the 24 Hours) 13° in the Ecliptic, the Globe muſt be turned about till that Arch of the Ecliptic ſhall aſcend the Horizon, which Motion of the Globe will be very little, as the Ecliptic now makes ſo ſmall an Angle with the Horizon, as is evident by the Index which now points to VI^{h} 17° for the Time of the Moon's riſing on the ſecond Day, which is but about ¼ of an Hour after Sun-ſet. The third Day, the Moon will riſe within ½ an Hour; on the 4th, within ¾ of an Hour, and ſo on; ſo that it will be near a Week before the Nights will be an Hour without Illumination: and in greater Latitudes this Difference will be ſtill greater, as you will eaſily find by varying the Caſe, in the Practice of this celebrated Problem, on the Globe.

Prob. XXXV. *To find the* TIMES *of the* YEAR *when the* SUN *and the* MOON *are ſubject to be* ECLIPSED.

Were the Moon to deſcribe the ſame Path in the Heavens with the Sun, or if ſhe always moved in the Ecliptic, there would always be a central and total Eclipſe of the Sun in every Conjunction, and a central Eclipſe of the Moon at every Oppoſition; and theſe Eclipſes would alternately return every Fortnight.

But, as the Caſe now ſtands, the Moon's Orbit not coinciding with the Ecliptic, but making an Angle of 5° therewith, there can be but two Points in the Ecliptic in which ſhe can ever be found in that Line; and as theſe two Points, or Nodes of the Moon's Orbit are diametrically oppoſite to each other, there are but two Days in the Year when it is poſſible for the Sun and Moon to be both together in the ſame Point of the Ecliptic, and, Conſequently, that a central, or total Eclipſe of the Sun can happen.

Now theſe two Days may be eaſily determined by finding the Places of the Moon's Node for the given Year, by Prob. XXIV, and then, when the Sun poſſeſſes that Degree of the Ecliptic, ſee what Days in the Month correſponds thereto in the Calendar, for they are the Times required for a central Eclipſe of the Sun.

Thus, for Inſtance: In the preſent Year, 1762, the aſcending Node is in the 11° 34′ of ♉, and the deſcending Node in the ſame Number of Degrees of ♏: By the Calendar

I obſerve, the Sun is in thoſe Points of the Ecliptic in *May* the 1ſt and *November* the 3d; but on thoſe Days our Almanack mention no Eclipſes, the Reaſon of which is, that, when the Moon paſſes her Nodes, the Sun is at ſome ſmall Diſtance from them, and the Eclipſes of the Sun, in ſuch a Caſe, can be only partial. Thus, the Moon paſt the aſcending Node in the preſent Year on the 24th of *April*, when the Sun was about 6° diſtant from the Node, as is evident by the *Ephemeris* for the Month of *April*. The ſame you will likewiſe obſerve for the Eclipſes in *November*, at the deſcending Node.

By the Doctrine of Eclipſes it is found, that the Sun muſt be within 12° of the Node to ſuffer an Eclipſe in any Degree; and the Moon within 16°, otherwiſe ſhe cannot enter the Earth's Shadow. Theſe Diſtances are, therefore, called the Ecliptic Limits for ſolar and lunar Eclipſes.

See this curious Part of Aſtronomy explained at large in my *Philoſophia Britannica*; as alſo in the *General* MAGAZINE *of* ARTS *and* SCIENCES.

CHAP.

PATENT OFFICE

CHAP. VI.

The Uſe of the CELESTIAL GLOBE *in the* SOLUTION *of* PROBLEMS *relative to the various* Phænomena *of the* PLANETS.

HAVING diſpatched the Problems relative to the SUN and MOON, we come now to thoſe of the PLANETS. In the Solution of *Planetary Problems*, the ſignal and important Uſe of the Celeſtial Globe will be no leſs conſpicuous than in the former, and muſt be very entertaining and advantageous, as by this Means we are always enabled to find how many, and what Planets are above the Horizon, and conſequently the proper Subjects for our Inſpection and Obſervation at any given Time of the Year.

But, as the Motion of ſome of the Planets are very quick, and even thoſe of the ſloweſt are very ſenſible in the Space of 12 Months, therefore it becomes neceſſary, by previous

Calculation, to have their Places aſcertained for every Day in the Year, (in the ſame Manner as for the Moon) in an *Ephemeris*; and hence it is we find five ſeveral Columns following that of the Moon's Latitude in the Table of Geocentric Motions, appropriated to the five Planets reſpectively, ſhewing the Sign, Degree, and Minute of the Ecliptic which each Planet poſſeſſes on the Noon of every Day throughout the Year. This is evident by Inſpection of the *Ephemeris*, for the *May* which we gave in the foregoing Chapter, (Page 45.) and is to be now conſulted for the Planets.

The Inclinations of the Planetary Orbits, or the Angle they make with the Ecliptic, is, in general, ſo ſmall as not to be regarded, except only for *Mercury*; and therefore the ſilken String, which was uſed for the Moon's Orbit, is not here neceſſary. The Problems, therefore, peculiar to the Planets are but very few, and their Solutions are as follow:

Prob. XXXVI. *To find the* PLACE *of the given* PLANET *in the* ECLIPTIC *for a given* TIME.

Look for the given Month in the *Ephemeris*, and oppoſite to the given Day of the Month is the Planet's Place in the Ecliptic, in the Column proper to that Planet. Thus, for Example: On *May* 9th, 1762, you will find

Saturn's

		°	′
Saturn's Place at Noon is	♈	18	26
Jupiter's	♈	24	48
Mars's	♎	16	46
Venus's	♉	29	30
Mercury's	♉	0	31

Having found theſe Places, you ſtick Patches on the reſpective Points in the Ecliptic, to denote them.

Prob. XXXVII. *To find the* PLACE *of a* PLANET *in its proper* ORBIT.

This Problem is inſerted for the Satisfaction of thoſe who have Mr. *Senex*'s large Globes of 17 or 28 Inches Diameter; becauſe, in them the Inclination of the Planetary Orbits to the Ecliptic appear conſiderable, (as a Degree in the latter Globes is full a Quarter of an Inch,) and that of *Jupiter*, which is the leaſt of all, is near 1° 30′: but *Mercury*'s greateſt Latitude is not much leſs than 7° 00′ and therefore, on this large Globe, it might anſwer in ſome Caſes to have the ſilken String repreſenting the Orbit of that Planet, as well as that of the Moon.

Having therefore found its Place in the Ecliptic, you will take out of a ſmall Table, on the Top of the Page, the Numbers proper to the Planet for the Day of the Month, neareſt to that of the given Day: This is the Planet's Latitude, North or South ac-

according as the Letters N. or S. ſtand above it. This Quantity of the Latitude is to be ſet off in the Circle of Latitude in the Planet's given Place, towards the North or South Pole of the Ecliptic, as the ſaid Letter N or S directs, and that is the Planet's true Place in its Orbit. Thus, on the 9th of *May*, 1762, I find the Latitude, in the Column for *Saturn* anſwering to the 7th Day, to be 2° 16′ South, which, therefore, is nearly the ſame as the 9th, and conſequently gives the Planet's apparent Place in the Southern Part of his Orbit. On this Point, therefore, the Patch muſt be put to repreſent the Planet's Place truly on the Surface of the Globe.

N. B. Tho' the Geocentric Latitudes of *Saturn* and *Jupiter* are nearly the ſame as their real Latitude, yet, that of *Mercury* will always be leſs, being ſeldom more than 4° 30′. On the Contrary, that of *Venus* and *Mars* will ſometimes much exceed the true Latitudes, as being at thoſe Times much nearer to us than the Sun.

Prob. XXXVIII. *To find the* TIME *when a given* PLANET RISES, CULMINATES, *or* SETS *on a given Day of the Year, and in a given Latitude.*

Rectify the Globe for the Latitude of the Place, bring the Sun's Place for the given

Day to the Meridian, and ſet the Hour Index to the upper XII: Then, having found the Planet's Place, bring it to the Eaſtern Edge of the Horizon, and the Index will point out the Time of its riſing. Then bring the ſaid Place, or Patch, to the Meridian, the Index will then ſhow the Time of its culminating, or being full South. Laſtly, turn the ſaid Patch into the Weſtern Edge of the Horizon, and the Index will there ſhew the Time of its ſetting.

For Example: On the 9th of *May*, 1762, at *London*, the Place of the Planet *Jupiter* was in ♈ 24° 48′: Then, rectifying the Globe, bring the ſaid Place to the Weſtern Horizon, and the Index will point to III Hours 20′, the Time of his riſing in the Morning: Then, revolving the Globe till the ſaid Point comes to the Meridian, the Index will ſhew the Time of its culminating to be 15′ after X; and bringing the ſaid Place to the Weſtern Part of the Horizon, the Index will point to 15′ after V, the Time of the Planet's ſitting.

From all which it evidently appears, that at that Time *Jupiter* was not to be obſerved in the Evening, and but a very little Time in the Morning; for, as he roſe but about half an Hour before the Sun, neither his Altitude nor the *Aurora* would permit his being viewed to any Advantage. And thus this Problem repeated for each of the Planets, will ſhew which of them are, or are not, in a Poſition to be ſeen in any given Day of the Year.

Prob. XXIX. *To find directly the* PLANETS *which are* ABOVE *the* HORIZON *at* SUN *ſet, upon any given* DAY *and* LATITUDE.

Find the Sun's Place for the given Day, bring it to the Meridian, ſet the Hour Index to XII, and elevate the Pole for the given Latitude: then bring the Place of the Sun to the Weſtern Semi-circle of the Horizon, and obſerve what Signs are in that Part of the Ecliptic above the Horizon, then caſt your Eye upon the *Ephemeris* for that Month, and you will, at once, ſee what Planets poſſeſs any of thoſe elevated Signs; for ſuch will be viſible, and fit for Obſervation on the Night of that Day.

Thus, for Example: On the 9th of *May* the Sun being in 19° 00′ of ♉, and in the Weſtern Horizon, the Signs in the Ecliptic will be *Gemini*, *Cancer*, *Leo*, *Virgo*, *Libra*, and *Scorpio*: But in the *Ephemeris* you will ſee only one of thoſe Signs poſſeſſed by a Planet, which is *Mars*, who is then in ♎ 16° 46′ in the Eaſtern Hemiſphere.

But then, two Signs more may be added for the Planets that may ariſe before Midnight for that Day, which, added to the former, make eight; but no Planet is found in them; therefore *Mars* will be the only Planet to be ſeen that Night.

Prob. XL. *To find when any of the three ſuperior* PLANETS *will* RISE *at* SUN-SET, *in a given Latitude.*

Rectify the Globe for the Latitude, and in the *Ephemeris* find the Planet's Place, which bring to the Eaſtern Part of the Horizon, then the Point of the Ecliptic, exactly oppoſite to the Planet's Place, will be in the Weſtern Part of the Horizon; and when the Sun comes to be in that Point, it will, of Courſe, ſet when the Planet riſes on that Day; and in the Calendar it may be ſeen, when the Sun poſſeſſes that Part of the Ecliptic, which will be the Time required.

But this is very eaſy to be obſerved in the *Ephemeris* only, by taking Notice of that Time of the Year when the Sun and the Planet poſſeſs two oppoſite Points in the Ecliptic; for, in this Oppoſition, the Planet muſt riſe when the ſun ſets.

Thus, for Example: On the 29th Day of *October*, 1762, the Sun and *Jupiter* will be in Conjunction, and conſequently the Planet will riſe when the Sun ſets.

But as to *Venus* and *Mercury*, as one is never ſeen to depart from the Sun more than 47° 00′, and the other not more than about 21°, the Times of their riſing at Sun-ſet will be eaſy to obſerve, among the Tables of mutual Aſpects, on the Right-hand Pages of the *Ephemeris*.

Prob. XLI. *To find the right* ASCENSION, DECLINATION, AMPLITUDE, AZIMUTH, ALTITUDE, HOUR *of the* NIGHT, *&c. of any given* PLANET, *for a Day of a Month and Latitude given.*

Rectify the Globe for the given Latitude and Day of the Month, then find the Planet's Place, as directed, and then the right Aſcenſion, Declination, Amplitude, Azimuth, Altitude, Hour, *&c.* are all found, as directed in the Problems for the Sun; there being no Difference in the Proceſs, no Repetition can be neceſſary.

But leſt any of our Readers ſhould have the Curioſity of performing theſe Problems according to the preciſe Truth, and would chuſe to repreſent their Orbits by a ſilken String, or Thread, as was directed in the Caſe of the Moon, it will be neceſſary to give here the Place of the Nodes, and Inclination of the Orbit, for each particular Planet, as below:

		°	'
The Place of the Node of the Orbit of	*Mercury*	15	2
	Venus	14	26
	Mars	18	30
	Jupiter	7	20
	Saturn	21	50

The Inclination of the Orbits of	*Mercury*	6	54
	Venus	3	24
	Mars	1	52
	Jupiter	1	20
	Saturn	2	30

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CHAP. VI.

The USE *of the Celeſtial* GLOBE *in the* SOLUTION *of* PROBLEMS *aſcertaining the* PLACES, *and* viſible MOTIONS *or* ORBITS *of* COMETS.

THERE is another Claſs, or Species of *Planets*, which are called COMETS. Theſe move round the Sun in regular and ſtated Periods of Times in the ſame Manner, and from the ſame Cauſe as the reſt of the Planets do, that is, by a centripetal Force, every where decreaſing as the Squares of the Diſtances increaſe, which is the general Law of the whole planetary Syſtem: But this centripetal Force in the Comets, being compounded with the projectile Force, in a very different *Ratio* from that which is found in the Planets, cauſes their Orbits to be much more Ecliptical than thoſe of the Planets, which are almoſt circular.

But whatever may be the Form of a Comet's Orbit in Reality, their Geocentric Motions, or the apparent Paths which they deſcribe in the Heavens among the fixed Stars, will always be circular, * and therefore may be ſhewn upon the Surface of a Celeſtial Globe, as well as the Motions and Places of any of the reſt of the Planets.

And to give the moſt ſignal Inſtance of the cometary Praxis on the Globe, I ſhall chuſe that Comet, for the Subject of theſe Problems, which made its Appearance at *Boſton* in *New England* in the Months of *October* and *November*, 1758, in its Return to the Sun; after which, it approached ſo near the Sun as to ſet *Heliocally*, or to be loſt in its Beams for ſome Time, ſpent in paſſing the *Perihelion*. Then afterwards, emerging from the ſolar Rays, it appeared retrograde in its Courſe from the Sun towards the latter End of *March*, and ſo continued the whole Month of *April* and Part of *May* in the *Weſt Indies*, particularly in *Jamaica*, whoſe Latitude rendered it viſible in thoſe Parts, when it was, for the greateſt Part of the Time, inviſible to us, by Reaſon of its Southern Courſe through the Heavens.

When two Obſervations can be made of a Comet, it will be very eaſy to aſſign its

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* This the Reader may ſee demonſtrated in my new THEORY of the COMETS.

Courſe, or mark it out upon the Surface of the Celeſtial Globe: Theſe, with regard to the above mentioned Comet, we have, and are ſufficient for our Purpoſe in regard to the Solution of Cometary Problems. By an Obſervation made at *Jamaica* on the 31ſt of *March*, 1759, at V o'Clock in the Morning, the Comet's Altitude was found to be 22° 50′, and its Azimuth 71° South Eaſt. From hence we ſhall find its Place on the Surface of the Globe, by the following Problem:

Prob. XLII. *To rectify the* GLOBE *for the Latitude of the Place of Obſervation in* JAMAICA, *Latitude* 17° 30′ *and given Day of the Month, viz.* March 31ſt.

Elevate the North Pole to 17° 30′ above the Horizon, then fix the Quadrant of Altitude to the ſame Degree in the Meridian, or Zenith-point: Again, the Sun's Place for the 31ſt of *March* is in 10° 34′ ♈, which bring to the Meridian, and ſet the Hour Index at XII, and the Globe is then rectified for the Place and Time of Obſervation.

Prob. XLIII. *To determine the* PLACE *of a* COMET *on the Surface of the Celeſtial Globe from its given* ALTITUDE, AZIMUTH, HOUR *of the* DAY, *and* LATITUDE *of the Place.*

The Globe being rectified to the given Latitude and Day of the Month, turn it about toward the Eaſt, till the Hour-Index points to the given Time, *viz.* V o'Clock in the Morning; Then bring the Quadrant of Altitude to interſect the Horizon in 71°, the given Azimuth in the South Eaſt Quarter; then, under 22° 50′, the given Altitude, you will find the Comet's Place, where you may put a ſmall Patch to repreſent it.

Prob. XLIV. *To find the* LATITUDE, LONGITUDE, DECLINATION, *and right* ASCENSION *of the* COMETS.

In the Circles of Latitude contained in the *Zodiac*, you will find the Latitude of the Comet to be about 3° 30′ from the Ecliptic; the ſame Circle of Latitude reduces its Place to the Ecliptic in 26° 30′ of ♒, which is its Longitude ſought. Then bring the Cometary Patch to the brazen Meridian, and its Declination will be ſhewn to be 9° 15′ South. At the ſame Time its right Aſcenſion will be 227° 30′.

Prob. XLV. *To ſhew the Time of the* COMET'S RISING, SOUTHING, SETTING, *and* AMPLITUDE *for the* DAY *of the Obſervation at* JAMAICA.

Bring the Place of the Comet into the Eaſtern Semi-Circle of the Horizon, (the Globe being rectified as directed,) the Index will point to III Hours 15′, which is the Time of its riſing in the Morning at *Jamaica*, the Amplitude 10° very nearly, to the South. The Patch being brought to the Meridian, the Index points to IX o'Clock 10′ for the Time of culminating, or being South to them. Laſtly, bring the Patch to touch the Weſtern ~~Meridian,~~ Horizon and the Index will point to III in the Afternoon, for the Time of the Comet's ſetting, with 10° of Southern Amplitude, of Courſe.

Prob. XLVI. *From the* COMET'S *Place being given, to find the Time of its* RISING *in the Horizon of* London, *on the* 31*ſt Day of* March, 1759.

For this Purpoſe, you need only rectify the Globe for the given Latitude of *London*, and bring the Cometary Patch to the Eaſtern Horizon, and the Index points to III Hours 45′ for the Time of its riſing at *London*, with about 14° of South Amplitude: then turn the Patch to the Weſtern Horizon, and the Index points to II Hours 25′, the Time of its ſetting.

N. B. From hence it appears, the Comet roſe ſoon enough that Morning to have been obſerved at *London*, had the Heavens been clear, and the Aſtronomers been before-hand apprized of ſuch a Phænomenon.

Prob. XLVII. *To determine another Place of the ſame* COMET, *from an* OBSERVATION *made at* LONDON *on the* 6th *Day of* May, *at* X *in the Evening.*

On the 6th Day of *May*, 1759, at X at Night, I very carefully obſerved the Place of the Comet, and meaſured its Diſtance, with a Micrometer, from two fixed Stars marked μ and ν in the Conſtellation called *Hydra*, and by an Azimuth Quadrant I found its Altitude 16°, and its Azimuth 37° S. W. from whence its Place on the Surface of the Globe is exactly determined, as in Prob. XLIII; and having ſtuck a Patch thereon, you will have the two Places of the Comet on the Surface of the Globe, for the two diſtant Days and Places of Obſervation, as required.

Prob. XLVIII. *From two given Places of a* COMET, *to aſſign its* apparent PATH *among the fixed Stars in the Heavens.*

The two Places of the Comet being determined by the Obſervations on the 31ſt of *March*, 1758, and the 6th of *May* following, and denoted by two Patches reſpectively, you muſt move the Globe up and down, in the Notches of the Horizon, till ſuch Time you bring both the Patches to coincide with the Horizon: Then will the Arch of the Horizon between the two Patches ſhew, upon the Celeſtial Globe, the apparent Place of the Comet in the Interval between the two Obſervations, and by drawing of a Line with a black Lead Pencil along by the Frame of the Horizon, its Path on the Surface of the Globe will be delineated, as required. And here it may be obſerved, that its apparent Path lay through the following Southern Conſtellations, *viz.* the Tail of *Capricorn*, the Tail of *Piſces Auſtralis*, by the Head of *Indus*, the Neck and Body of *Pavo*, through the Neck of *Apus*, below *Triangulum Auſtrale*, above *Muſca*, by the Lowermoſt of the *Croſiers*, acroſs the hind Legs and through the Tail of *Centaurus*, from thence between the two Stars in the Back of the *Hydra*, before mentioned; after this, it paſſes on to *Sextans Uraniæ*, and then to the Ecliptic near *Cor Leonis*; ſoon after which, it totally diſappeared.

Prob. XLIX. *To eſtimate the apparent* VELOCITY *of a* COMET, *from two Places thereof being given by Obſervation.*

Let one Place be aſcertained near the beginning of its Appearance, and the other towards the End thereof; then bring theſe two Places to the Horizon, and count the Number of Degrees interſected between them, which, being the Space apparently deſcribed in a given Time, will be the Velocity required. Thus, in the Caſe of the abovementioned

Comet, you will find, that it deſcribed more than 150° in the Space of 36 Days, which is more than 4° *per* Day.

Prob. L. *To repreſent the general Phænomena of the* COMET, *for any given Latitude.*

Bring the viſible Path of the Comet to coincide with the Horizon, by which it was drawn, and then obſerve what Degree of the Meridian is in the North Point of the Horizon, which, in the Caſe of the foregoing Comet, will be the 23°: This will ſhew the greateſt Latitude in which the whole Path can be viſible in any Latitude leſs than this, as that of *Jamaica*: Where, for Inſtance, the moſt ſouthern Part of the Path will be elevated more than 5° above the Horizon, and the Comet viſible thro' the whole Time of its Apparition. But rectifying the Globe for the Latitude of *London*, the Path of the ſaid Comet will be for the moſt Part inviſible, or below the Horizon; and therefore it could not have been ſeen in our Latitude, but at Times very near the Beginning and End of its Appearance; becauſe, by bringing the Comet's Path on one Part to the South Point of the Horizon, it will immediately appear in what Part the Comet ceaſes to be viſible: And then bringing the other Part of the Path to the Point, it will appear in what Part it will again become viſible.

After this Manner may the Problems relating to any other Comets be performed, and ſo the Paths of the ſeveral Comets, which have hitherto been obſerved, may be ſeverally delineated on the Celeſtial Globe, and their various Phænomena in different Latitudes thereby ſhewn.

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CHAP. VIII.

The USE *of the* Celeſtial GLOBE *in the* SOLUTION *of* PROBLEMS *relative to the* fixed STARS.

WE now proceed to thoſe Problems on the Celeſtial Globe in which the STARS are concerned, which, with reſpect to the preſent Age, we may very well conſider as *fixed*, ſince their Motion is ſo exceeding ſlow as not to be ſenſible in leſs than Half a Century: And their Places having been very carefully rectified by Mr. *Senex* but a few Years ago, as we intend not here a Philoſophical Diſcourſe on the Stars, ſhall only obſerve, that they are ranged into various Conſtellations on the Surface of the Celeſtial Globe, as artificial Helps for directing us how to know, and where to find them in the Heavens. The Names of theſe Conſtellations are to be learnt by Inſpection of the Globe, where they appear very plain; as alſo their Forms and Diſpoſition, you will find the Stars depicted in different Degrees of Magnitude, as they appear to the Eye, the largeſt being called Stars of the firſt Magnitude; and upon the Globes you will ſee them decreaſed to the 6th or 7th Magnitude. Whenever you are to perform any Problem of the Stars on the Globe, it is ſuppoſed that you have rectified the Globe for the Latitude of the Place, and for the Sun's Place for the given Day at Noon, as in all the other Problems, and then the Proceſs will be very eaſy and ſhort.

Prob. LI. *To find the right* ASCENSION *and* DECLINATION *of any given* STAR.

Bring the given Star to the Meridian, and the Degree under which it lies is its Declination; and the Point in which the Meridian interſects the Equinoctial is its right Aſcenſion. For Inſtance, let *Arcturus* be the given Star, this brought to the Meridian will be ſeen under the 20° 20′, which is therefore its Declination, North; and its right Aſcenſion is, at the ſame Time, ſhewn in the Equinoctial to be 211° 00′. Again, another Inſtance may be *Sirius*, the *Dog-ſtar*, which, brought to the Meridian, will be ſeen under the 16° 30′, which is his Declination, South; and its right Aſcenſion 98° 20′ in the Equinoctial Line.

Prob. LII. *To find the* LATITUDE *and* LONGITUDE *of a given Star.*

Bring the Pole of the Ecliptic to the Meridian, over which fix the Quadrant of Altitude, and, holding the Globe very ſteady, move the Quadrant to lie over the given Star, and it will cut that Degree in the Edge as will ſhew its Latitude from the Ecliptic, and in the Ecliptic the Quadrant will cut that Degree which is called its Place *reduced to the Ecliptic*, or Longitude, from the Beginning of *Aries*. Thus, with reſpect to *Arcturus*, its Latitude from the Ecliptic will be found 30° 30′, and its Longitude in the Ecliptic about 20° 20′ of *Libra*. This Problem regards either Pole, as the Stars are in the Northern or Southern Hemiſpheres, reſpectively.

Prob. LIII. *The right* ASCENSION *and* DECLINATION *of a Star being given, to find its Place on the Globe.**

Turn the Globe till the Meridian cuts the Equinoctial in the Degree of right Aſcenſion: Thus, for Example: ſuppoſe you find in the Table the right Aſcenſion of *Aldebaran* to be 65° 30′, and its Declination to be 16° North, then turn the Globe about till the Meridian cuts the Equinoctial in 65° 30′, and under the 16° of the Meridian, on the Northern Part, you will obſerve the Star *Aldebaran*, or the *Bull's Eye*.

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* See the Table of right *Aſcenſion* and *Declination* of the Stars at the End of this Chapter.

Prob. LIV. *To find the Time of the riſing, ſouthing, ſetting, Amplitude, &c. of any* STAR *in a given* LATITUDE *and* DAY *of the* YEAR.

The Precept is the ſame as in the Problems for the Sun. Thus, let it be required to know at what Time the *Pleiades* (or *Seven-ſtars*) riſe, ſet, *&c.* in the Latitude of *London*, on the 11th of *May*. The Globe being rectified for the Latitude of *London*, and the Sun's Place for the given Day, turn the Globe about till you bring the *Pleiades* into the Eaſtern Semi-circle of the Horizon, and the Index will Point to 34° 45′ the Time of their riſing in the Morning.——Then bring the ſaid Cluſter of Stars to the Meridian, and the Index will point to about ½ after XII for the Time of their culminating, or being upon the Meridian.——Laſtly, bring them into the Weſtern Horizon, and the Index will point to VIII 40′, which ſhews the Time of their ſetting in the Evening of that Day.——It will alſo appear, on the Circle of the Horizon, that they riſe with about 40° of Amplitude to the North, and ſet with the ſame Amplitude from the Weſt.

Prob. LV. *To find when a* STAR RISES *and* SETTS COSMICALLY, *in a given* LATITUDE.

Rectify the Globe to the Latitude of the Place, and bring the given Star to the Eaſtern Part of the Horizon, then obſerve what Point of the Ecliptic riſes with it, and find the ſame Degree of the Ecliptic upon the Frame of the Horizon, againſt which is the Day of the Month when the given Star riſes Coſmically. ——— Afterwards, bring the given Star to the Weſtern Edge of the Horizon, and obſerve what Degree of the Ecliptic riſes in the Eaſtern Part, then the Day of the Month in the Calendar,. which anſwers to that Degree, is the Time when the Star ſets Coſmically.

For Example: *Mencar*, in the *Whale's Mouth*, riſes with the 11° of *Gemini*, in the Latitude of *London*, and therefore riſes Coſmically on the firſt Day of *June*. Again, by bringing the Star *Mencar* to the Weſtern Part of the Horizon, I find the 2° of *Sagittarius* riſing in the Eaſt, anſwering to which is the 24th Day of *November*, the Time on which that Star ſets Coſmically.

Prob. LVI. *To find the* TIME *when any* STAR *will* RISE *or* SET ACRONICALLY, *in a given Latitude.*

The Example will here be ſufficient: Therefore, let *Sirius*, or the *Dog-Star*, be brought to the Eaſtern Edge of the Horizon, and then obſerve what Degree of the Ecliptic is in the Weſtern Part of the Horizon, which you will find to be the 18° of *Aquarius*, againſt which the 7th Day of *February* in the Calendar, the Time when the *Dog-Star* riſes Acronically, or at Sun-ſet, and, conſequently, when it begins to be viſible in the Evening.

Then, for the Acronical ſetting of the *Dog-Star*, turn the Globe about till he is ſetting in the Weſtern Horizon, and ſee what Degree of the Ecliptic is, at the ſame Time, ſetting with him, which you will find is about 23° of *Taurus*; and therefore, about the 13th of *May*, this Star ſets Acronically, or with the Sun, and conſequently is no longer to be ſeen in the Evening.

Hence it is plain, thoſe Months of the Year which intervene between the Acronical riſing and ſetting of the Star, is the Space of Time in which that Star may be ſeen above the Horizon, of the given Latitude, in an Evening.

Prob. LVI. *To find when any* STAR CULMINATES, *or comes upon the Meridian with the* SUN.

Bring the given Star to the Meridian, and obſerve what Degree of the Ecliptic comes upon the Meridian with it, and againſt that Degree is the Day of the Month, in the Calendar, required.

For Example: Let the given Star be *Cor Hydra*, which bring to the Meridian, and you will obſerve the 15° of *Leo* interſected by the Meridian at the ſame Time; againſt which, in the Calendar, is the 8th Day of *Auguſt*, which is the Day required, when that Star Culminates with the Sun.

Prob. LVII. *To find what Time of the Year a Star is upon the Meridian at Midnight.*

Bring the given Star to coincides with the nocturnal Part of the Meridian, and then obſerve what Point of the Ecliptic is interſected by the diurnal Part of the Meridian, and the Day when the Sun poſſeſſes that Part of the Ecliptic, which you will ſee, by the Calendar, is the Time required. Thus, for Example: the Star called *Deneb* in the Tip of the *Great Bear*'s *Tail*, being brought to the nocturnal Meridian, the Degree of the Ecliptic lying under the South Semi-circle of the Meridian, is the 27° of *Aries*, againſt which is the 17th Day of *April*, the Day of the Month on which that Star will be on the Meridian at XII at Night.

Prob. LVIII. *To find the* OBLIQUE ASCENSION *of a given Star, and thereby the Time of its being above the Horizon in a given Latitude.*

This Problem is performed in the Manner already preſcribed for the Sun, Moon, and Planets. Thus, for *Aldabaran*, rectify the Globe to the given Latitude, and you find its right Aſcenſion, by Prob. LIII, to be 65° 30′; by bringing the Star to the Eaſtern Horizon, his oblique Aſcenſion will appear to be 41° 30′: The aſcenſional Difference therefore is 24°, which, converted into Time, is 1^h 36′, which, added to 6^h, makes 7^h and $\frac{1}{2}$, the Time which that Star is above the Horizon in the given Latitude; and therefore the whole Time is 15^h 12′.

Prob. LIX. *In a given Latitude, Day of the Year, and Hour of the Night, to find the* ALTITUDE *and* AZIMUTH *of a given* STAR.

Rectify the Globe to the given Latitude, and Day of the Year, then ſet the Hour Index to the given Hour, and move the Quadrant of Altitude to the given Star, its Azimuth will then appear in the Horizon, and its Altitude on the Edge of the Quadrant.

For Example: In the Latitude of *London*, the 11th of *May*, at XI o'Clock at Night, I find the Altitude of *Cor Leonis*, or *Lion's Heart*, to be 26° 30′, and its Azimuth 76° 30′ from the South towards the Weſt, or nearly Weſt by South.

Prob. LX. *From the obſerved Altitude of a Star, to find the Hour of the Night in* *in a given Day of the Year, and in a known Latitude.*

Rectify the Globe for the given Latitude and Day of the Year, then turn the Globe about in ſuch a Manner that the Star may be upon the Edge of the Quadrant in the given Degree of Altitude, then will the Index point to the Hour of the Night. This is but the Converſe of the former Problem, and therefore needs no Example.

Prob. LXI. *From the obſerved* HOUR *and* MINUTE *of a* STAR'S RISING, *or* SETTING *on a given Day, to find the* LATITUDE *of the Place.*

Rectify the Globe to the given Day, and turn it about till the Index points to the given Hour and Minute, where keeping it ſteady, let the Brazen Meridian be moved up and down in the Notches of the Horizon till the given Star touches the ſame, then will the Degrees of the Meridian, interſected by the North Part of the Horizon, ſhew the Elevation of the Pole, and conſequently the Latitude of the Place.

For Example: Suppoſe, on the 11th of *May* at IV in the Morning, I obſerve the bright Star in *Caput Meduſæ* riſing; then by rectifying, and moving the Globe as above directed, the Latitude of the Place will be found to be 24° 30′ North.

Prob. LXII. *From an Obſervation of two known Stars being upon the ſame Azimuth in a given Latitude, to find the* HOUR *of the Night.*

Rectify the Globe for the Latitude, and the Sun's Place on the given Day, then turn the Globe about in ſuch a Manner, and alſo the Quadrant till its Edge lies over both the given Stars preciſely, then will the Index point to the Hour of the Night.

Thus, for Example: on the 11th of *May*, in the Latitude 51° 30′, the two Stars called *Lucida Lyræ* and *Alcair* will both be on the ſame Azimuth at ¼ paſt II in the Morning.

Prob. LXIII. *From an Obſervation of two known* STARS *having the ſame* ALTITUDE, *to find the* HOUR *of the* NIGHT.

Rectify the Globe to the given Latitude and Day of the Month, then move the Globe about ſo that the ſame Degree of the Quadrant may cut both the given Stars, then will the Index point to the Hour of the Night.

For Example: On the 11th of *May*, in Latitude 51° 30′, the bright Star in *Pegaſus*'s Wing, and that in the Head of *Andromeda*, will both of them have an equal Altitude at Half an Hour after II in the Morning.

N. B. This and the foregoing Problems are uſeful when the Quantity of the Azimuth, or the Altitude of the two Stars is not known; for, by a Plumb-line only, it may be known when any two Stars have the ſame Azimuth; and any Staff, *&c.* moved parallel to the Horizon, will give the equal Altitude of two known Stars with Eaſe

Prob. LXIV. *From an Obſervation of a known Star in the Meridian, and another in the Eaſt, or Weſt Part of the Horizon, to find the Latitude of the Place.*

Bring the Star that was obſerved in the Meridian to the Meridian of the Globe, and keep the Globe from moving round its Axis, then ſlide the Globe up and down in the Notches, till the other Star is brought to the Eaſt, or Weſt Part of the Horizon, and that Elevation of the Pole will ſhew the Latitude of the Place.

Thus, for Example: When *Sirius* is upon the Meridian, *Arcturus* will be upon the Eaſtern Part of the Horizon in the Latitude of 44° 40′

Prob. LXV. *From the obſerved Altitude of two Stars on a given Azimuth, to find the Latitude of the Place.*

Set the Quadrant over both Stars of the obſerved Degrees of Altitude, and there keep it from moving, then ſlide the Meridian up or down in the Notches 'till the Quadrant cuts the given Azimuth in the Horizon; then the Elevation of the Pole will be the Latitude required.

For Example: *Cor Hydræ*, and *Procyon* or the little *Dog Star*, are both on the Azimuth of 78° 45′ South Eaſt, one with 5° of Altitude and the other with 35°, in the Latitude of 26° 30′.

Prob. LXVI. *To find the Circle, or Parallel of perpetual Apparition, or Occulation of a fix'd Star in a given Latitude.*

By rectifying of the Globe to the Latitude of the Place, and turning it round on its Axis, it will be immediately evident, that the Circle of perpetual Apparition is that Parallel of Declination which is equal to the Compliment of the given Latitude Northward; and for the perpetual Occulation, it is the ſame parallel Southward, that is to ſay, in other Words, all thoſe Stars whoſe Declinations exceed the Co-Latitude will always be viſible, or above the Horizon; and all thoſe in the oppoſite Hemiſphere, whoſe Declination exceeds the Co-Latitude, never riſe above the Horizon.

For Inſtance: In the Latitude of *London* 51° 30′, whoſe Co-Latitude is 38° 30′, gives the Parallels deſired; for all thoſe Stars which are within this Circle, towards the North Pole, never deſcend below our Horizon; and all thoſe Stars which are within the ſame Circle, about the South Pole, can never be ſeen in the Latitude of *London*, as they never aſcend above its Horizon.

Prob. LXVII. *To repreſent the* FACE *of the* HEAVENS *on the* GLOBE *for a given Hour on any Day of the Year.*

Rectify the Globe to the given Latitude of the Place and Day of the Month, ſetting it due North and South by the Needle, then turn the Globe on its Axis till the Index points to the given Hour of the Night: Then all the upper Hemiſphere of the Globe will repreſent the viſible Face of the Heavens for that Time, by which it will be eaſily ſeen what Conſtellations and Stars of Note are then above our Horizon, and what Poſition they have with reſpect to the Points of the Compaſs. In this Caſe, ſuppoſing the Eye was placed in the Center of the Globe, and Holes were pierced through the Centers of the Stars on its Surface, the Eye would perceive through thoſe Holes the various correſponding Stars in the Firmament; and hence it would be eaſy to know the various Conſtellations at Sight, and to be able to call all the Stars by their Names.

The Uſe of this Problem is moſt extenſive, as it acquaints us at any Time with the apparent Face or State of the Heavens, and ſhews us when the Moon, or any of the Planets, may be ſeen, or fit for Examination by the Teleſcope. We can alſo from hence learn, when any of thoſe curious and wonderful Objects, called *Nebulous* STARS, may be ſeen, and which ſtrike the Mind of the Obſerver with Amazement, by preſenting to his View an indefinite Number of the ſmalleſt fixed Stars through the whole Field of View in his Teleſcope.——From hence alſo, the Poſition of that very extraordinary Phænomenon called the *Galaxia*, or *Milky-way*, is at any Time known; and from hence thoſe ſilly and ſuperſtitious Notions of its having Relation to the Wind, with other aſtrological Fooleries, will intirely vaniſh.——This ſingle Problem, therefore, may be conſidered in its ſelf as ſufficient to recommend the Uſe of the Celeſtial Globe, to every ſtudious and rational Mind, as the moſt neceſſary Inſtrument of his Celeſtial Tuition.

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CHAP. IX.

The Method of conſtructing the Celeſtial GLOBE *with a* moveable ECLIPTIC *and* EQUINOCTIAL, *to render its* USE *Univerſal for all* AGES *of the* WOLRD.

IT has been ſhewn, in a great Variety of the moſt uſeful Problems, how neceſſary and valuable an Inſtrument the Celeſtial Globe is; but it muſt, at the ſame Time, be conſidered, that as all the Stars have a ſlow progreſſive Motion from Weſt to Eaſt, at the Rate of *one Degree* of right Aſcenſion in 72 Years, the Uſe of a Celeſtial Globe, as they are commonly made, cannot be ſo extenſive, as, in ſome Caſes, might be deſired: For, ſince the Stars are continually moving out of their Places, we cannot repreſent the Face of the Heavens as they were many Ages paſt, or as they will appear to thoſe who ſhall live in future Ages; and ſince the Celeſtial Globe is capable of a Conſtruction that ſhall entirely prevent this Deficiency of its Uſe, by rendering it fit to repreſent the true State of Appearance of the Heavens for any Age of the World indifferently, I thought proper here to recommend it to the Ingenious and Inquiſitive in the Study of Aſtronomy, by ſhewing wherein this *new Conſtruction*, or *Apparatus* of this Celeſtial Globe does conſiſt, and then to illuſtrate its Uſe by proper and adequate Examples.

The late Mr. *Senex*, amongſt many other Improvements of the Globe, contrived by Means of two Braſs Arms ſcrewed upon the Poles of the Ecliptic at one End, and in the other (at the Diſtance of 23° 30′) there were fixed Pieces of Iron-wire to repreſent the two Ends of the Earth's Axis, or Poles of the World; theſe were placed as uſual in proper Grooves in the Brazen Meridian, and the Globe moveable upon, or about them, as in thoſe of the common Conſtruction: ———From hence, it is eaſy to underſtand, that, by looſening the Screws in the Pole of the Ecliptic, any Degree of angular Motion about them might very eaſily be given to the Poles of the World, and conſequently that the ſaid Poles of the World might have any Poſition required with reſpect to the Poles of the Ecliptic, and thereby the Colures might be conceived as moving through all the Points of the Ecliptic in the Space of 25,920

Years, in which Period of Time all the different Phaſes of the Heavens will return again, and ſucceed in the ſame Order perpetually; and that, in any particular Part of this Period, the Appearance of the Stars and the Seaſons of the Year will be very different in the Heavens and in the Calendar, from what they will be at any other conſiderable Diſtance of Time.

But, to repreſent this Difference in the moſt natural and eaſy Manner, I have found the following additional Parts of our Apparatus to be neceſſary, and therefore have added them: (1) Two *moveable* equinoctial and ſolſtitial *Colures.* (2) A *moveable equinoctial Circle.* (3) A *moveable Ecliptic.*——Theſe are all ſo connected together, that they repreſent the Situation of thoſe imaginary Circles in the Heavens for any Age of the World, and the Situations, or Places of the Stars and Conſtellations reſpectively thereto, hereby rendering the Celeſtial Globe of univerſal and perpetual Uſe, as we ſhall now proceed to illuſtrate in the Solution of the following uncommon Problems, which we make no doubt will afford equal Pleaſure and Amuſement to the young Aſtronomer.

Prob. LXVIII. *To rectify the Globe for any paſt* AGE *of the World propoſed.*

We are here to obſerve, that the Latitude of the Place is not affected by this Motion of the Poles of the World about the Poles of the Ecliptic, but continues the ſame in every Age: Therefore, to rectify the Globe for any given Age, you have no more to do than only to looſen the Screws on the Poles of the Ecliptic, and thereby give the Poles of the World ſo much Motion as is neceſſary for that Diſtance of Time, at the Rate of *one Degree in* 72 *Years*; which being done, let the Braſs Arms be again ſcrewed faſt on the ecliptic Poles; then will all the Stars, with regard to the Colures, Ecliptic, and equinoctial Lines, have the ſame Poſition and Appearance as they had in the given Age.

For Example: It is ſaid, that *Hipparchus*, the firſt conſiderable Aſtronomer, lived about 2000 Years ago; therefore, the Globe being rectified for that Age, the Poles of the World muſt be moved forward about the Poles of the Ecliptic 27° 30′ and there fixed: ——In Conſequence of this, the vernal equinoctial Point, or Beginning of the Sign ♈ *Aries* will be carried forward in the Ecliptic 27° 30′, by which Means the equinoctial Colure will paſs very near to the bright Star in the Head of *Aries*, and there, *Hipparchus* tells us, it really was in his Time.——At this Time, therefore, it plainly appears by the Globe, that all the Conſtellations of the *Zodiac* were ſeen in the ſame Signs of the Ecliptic, which bear their Names; very different from the Poſition and Appearance of thoſe Conſtellations in the *preſent Age.*

Prob. LXIX. *To ſhew the Quantity of the* RECESSION, *or retrograde Motion of the equinoctial Points, from* AGE *to* AGE.

Rectify the Globe for any diſtant given Age, then will the Degrees in the Ecliptic, contained between the preſent equinoctial Points and thoſe of the given Age, be the Quantity of the *Receſſion* required.

Thus, for Example: In the Age of *Hipparchus* there are 27° 30′, by which the equinoctial Points have gone backward thro' the Ecliptic, or ſo much are they at preſent diſtant from the Poſition they had in his Time.

Prob. LXX. *To Rectify the* GLOBE *for any propoſed* FUTURE AGE.

This is done by looſening the Screws in the Poles of the Ecliptic, and thereby giving the Poles of the World ſo much of their retrograde angular Motion as is required for the Age propoſed, at the Rate of one Degree in 72.

Thus, for Example: Let it be required to rectify the Globe for the People who ſhall live 6500 Years hence, which being one fourth Part of the whole Period, it is plain the Poles of the World muſt have retrograded through one fourth of a Circle, or 90°:

Then will the People of that Age obſerve the following Differences in the State of the Heavens from the Preſent, (1.) That the equinoctial Points will then be in the Beginning of *Capricorn.* (2.) The vernal equinoctial Day will then happen upon the 22d of *December*, which is now our Midwinter Day. (3.) That the Stars will all appear to have advanced forward, or changed their Longitude three whole Signs, or 90° in that Time. (4.) The Conſtellations of the *Zodiac* will be removed four Signs from the Beginning of the *Ecliptic*, *i. e. Aries* will be in *Leo*, and ſo on. (5.) As the moveable Equinoctial Line will then contain an Angle with the preſent, ſo the Declination of the Stars will be much altered thereby. (6.) For thoſe that had none before, may now have a Declination of any Quantity leſs than 24°. (7.) Many Stars will have changed their Declination in that Time: Thus, in the preſent Age, *Cor Leonis* has 14° Declination N. in that Age its S. Declination will be greater. (8.) The Stars and Conſtellations which are always viſible to us, will, many of them, then riſe and ſet: Thus the *Greater Bear*, which at preſent goes not very near the Horizon, will, in that diſtant Age, be got almoſt wholly below it. (9.) Many Stars and Conſtellations which now riſe and ſet, will then be conſtantly viſible, as *Delphinus*, *Vulpecula*, *Andromeda*, *&c.* (10.) Stars which are at preſent inviſible, will then become viſible unto us. (11.) The preſent Pole Star will then circulate round the North Pole of the World. (12.) A Point in the Heavens between the Right-hand and Head of *Cepheus* will then be the North Pole of the World. (13.) Many Stars viſible in our Age, will be wholly inviſible to them. (14.) In that Age, very different Stars will riſe, culminate, and ſet with the Sun, to what do now. (15.) The Right Aſcenſion, Altitudes, and Azimuths will all undergo proportionable Changes, from what they have in the preſent Age.

Theſe, and many other Phænomena, may be looked upon as ſo many particular Problems to be wrought on this new conſtructed Celeſtial Globe alone: But when the Globe is rectified for any particular Age, the Problems are the ſame as thoſe we have already ſpecified in the Uſe of the common Globe for the preſent Age; and therefore, as the Reader can find no Difficulty in repeating them in that Caſe, we have, for Brevity Sake, only juſt mentioned them here.

Prob. LXXI. *To find the Diſtance of the Age in which any Perſon lived, from Celeſtial Obſervations recorded by him.*

Having looſened the Screws on the Poles of the Ecliptic, let ſuch a Motion be given to the Poles of the World, and to the ſeveral moveable Circles, as will render the Globe fit for exhibiting and verifying the given Obſervation upon Record; and there ſcrew them faſt: Then find the Arch of the Ecliptic interſected between its Poſition at that Time and the preſent, this, converted into Time, allowing one Degree to 72 Years, will give the Diſtance of Time required.

For Example: HESIOD the Poet, tells us, that, in his Time 60 Days after the Sun had paſt the Winter Solſtice, and was, of Courſe, in the Beginning of *Piſces*, the Star *Arcturus* was riſing in the Eaſt at the Time of Sun-ſet. Now, in order to qualify the Globe to exhibit the ſame Phænomenon when the Sun is in that Part of the Ecliptic, we muſt firſt rectify the Globe for the Latitude of *Aſcra* in *Greece*, where *Heſiod* lived, which was 38° N. and having done this, the Poles of the World muſt be moved one Way and the other, about the Poles of the Ecliptic, 'till ſuch Time the Sun's Place (in the Beginning of *Piſces*) and the Star *Arcturus* ſhall be both at the ſame Time in the Horizon, in which Caſe let the Braſs Arm be faſtened, and then you will obſerve the Equinoctial Points to have been moved forward in the Eliptic to the 6° of *Taurus*, or 36°. This, therefore, is the Space in which they have receded ſince *Heſiod*'s Time, which therefore muſt have been at the Diſtance of 36 times 72, or 2592 Years from the preſent Time; which proves him Contemporary with *Jehu* King of *Iſrael*,

and

and *Jonah* the Prophet, according to our beſt Chronologers.

N. B. *Heſiod* further tells us, that at the ſame Time that *Arcturus* was riſing, the *Dog Star*, and the Conſtellation *Orion*, poſſeſſed the Mid-Region of the Heavens, and thus they appear on the Globe rectified for his Age: but in the preſent Age, no ſuch Phænomena of thoſe Stars appear with the ſetting Sun in that Part of the Ecliptic. The ſame Problem may be performed for other Obſervations, recorded by the Poets and Philoſophers of antient Times, as *Ovid*, *Virgil*, *Ptolemy*, *&c.* and thus the celeſtial Globe will be found moſt eminently uſeful in the Science of Chronology.

It may be proper here to mention, that I have by me the Copy of a very antique Globe, which was found in the Ruins of ancient *Rome*, and is now in the *Muſæum* of the *Farneſian* Palace, reſerved as the moſt curious Monument of Antiquity: It is about 13 Inches in Diameter, and has upon it the various Conſtellations as they were depicted by the Ancients, and, amongſt them, thoſe of the *Zodiac* poſſeſſing ſeverally the Signs bearing their own Names; together with the Equinoctial Lines, Ecliptic, and Colures: The Equinoctial Colure paſſing through the right Horn and Foot of *Aries*, not far from the Equinoctial Point, *viz.* about 5°, which ſhews that this Globe might probably be made about 360 Years after the

Colure was in the Equinoctial Point. But ſince this Situation of the Colure on this antique Globe, the Equinoctial Point has receded 25° more, which, in Time, gives 1800 Years: Which plainly ſhews it to have been made ſome Years before the Birth of Chriſt. Therefore, this Globe is a Proof that the Equinoctial Colure paſſed through the bright Star of *Aries* nearly 2200 Years ago, agreeable to what we obſerved before, with regard to the Time and Obſervations of *Hipparchus*.

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CHAP. X.

The USE *of the* Celeſtial GLOBE *in* DIALLING.

THE principal Uſe of the Celeſtial Globe in Dialling is rather to give the *Rationale*, or general Reaſon of the Proceſs in the Conſtruction of different Kinds of Dials, than to give an accurate and practical Method of delineating Dials univerſally. A Perſon totally unacquainted with the Nature and Uſe of the Globe is wholly mechanical in theſe Operations; he works by Rules, and is ſure to ſucceed, which is all the Satisfaction he can have; but one who is ſkilled in the Uſe and Projection of the Globe may be ſaid to conſtruct Dials in a rational Manner, having the Light of Reaſon to direct and elucidate all his mechanical Operations: For when his Globe is rectified, the whole Dial riſes before him to his View. ——— The Pole is elevated to its proper Height :——The Hour-circles all appear in their natural Poſition : —— Their In-

Interſections with the Horizon give the angular Poſition of the Hour-lines, with the Meridian: ——— The Poſition of the Gnomon, and ſubſtyle in all declining Dials, are ſhewn to have that Poſition, neceſſarily among the Hour-lines of the Plane, which the Rules of Practice preſcribe: ——To ſuch a Perſon, therefore, every Thing muſt appear natural and eaſy.

But ſince an *horizontal Dial* for any Latitude is, of all others, the moſt uſeful, and can be very accurately made even by the Globe itſelf, without any other help; and alſo a *direct South*, and *North Dial*, for the ſame Latitude, is made with equal Eaſe and Correctneſs, we ſhall therefore, in Conformity to our general Method, deliver theſe Conſtructions in the following Problems.

Prob. LXXII. *To conſtruct an* HORIZONTAL DIAL *for any given* LATITUDE, *by Means of the* GLOBE *alone.*

The Proceſs conſiſts in the following Particulars: (1) On a Piece of clean Paper, or Board, which is deſigned for the Plane of the Dial, let a Circle be deſcribed, (as large as can be admitted) through the Center of which draw two lines, interſecting each other at right Angles; one of theſe will be the Meridian Line of North and South, and the other will repreſent the prime vertical of Eaſt and Weſt.

(2) Let this Circle be divided into 4 Times ninety Degrees, numbering them each Way into 10, 20, 30, 40, *&c.* from the North and South Parts of the Meridian Line towards the Points of Eaſt and Weſt.

(3) Let the Globe be rectified and elevated to the Latitude of the given Place, as, ſuppoſe LONDON 51° 30′, then will the Axis of the Globe have the ſame Elevation above the Horizon as the Gnomon, or Style of the Dial, muſt have above the Plane thereof, *viz.* 51° 30′.

(4) Becauſe the fixed or brazen Meridian of the Globe muſt neceſſarily repreſent the Hour-circle of XII, therefore the Meridian Diameter of the Circle muſt be continued out to the Border of the Dial, (the Form of which is ſuppoſed to be a Parallelogram,) at the North Part of which you place the Hour XII.

(5) Then if your Globe has Meridians drawn on its Surface through every 15° of the Equinoctial, (as on *Senex*'s Celeſtial Globes they are,) then will thoſe Meridians repreſent the true Hour-circles of the Sphere, and will interſect the Horizon of the Globe in certain Points on each Side the Meridian, which you muſt very carefully obſerve, and note down upon a Piece of Paper, as in the following Table:

(6) Then,

Hour:		
12	00	00
1	11	51
2	24	19
3	38	3
4	53	36
5	71	6
6	90	

(6) Then laying a Ruler from the Center of the Circle to each of thoſe Points, or Diviſions, you draw from the Circle ſtrait Lines to the Border of the Dial in each North Quadrant of the Circle, and againſt them write the ſeveral Hours reſpectively, *viz.* XI, X, IX, VIII, VII, VI, on the North-Weſt Quadrant, for the Morning Hours; and I, II, III, IV, V, VI, for the Hours of the Afternoon.

N. B. It is here ſuppoſed, that one of the Meridians on the Globe coincides preciſely with the graduated Edge of the brazen Meridian; then all the Hour-Circles, on each Side the Northern Part of the Meridian, interſect the Horizon at equal Diſtances from it reſpectively.

(7) Then, becauſe in all Latitudes the longeſt Day exceeds XII Hours, there muſt be more than XII drawn upon an horizontal Dial. And, becauſe in the Latitude of *London* the longeſt Days do a little exceed XVI Hours, therefore the Hour-lines on ſuch horizontal Dials, muſt, at leaſt, be *Sixteen*; therefore,

(8) Since the Hour-Circle of VII interſects the Horizon at an equal Diſtance from the Eaſt Point, as does the Hour-Circle of

V, and the ſame may be ſaid of the Hours V and VII in the Morning, on the Weſtern Part of the Horizon, it is evident, a Ruler laid from the Hour of VII in the Morning thro' the Center of the Circle, will give the oppoſite Hour-line for VII in the Evening on the Eaſtern Side of the Dial: in the ſame Manner, the Ruler laid from the Hour of VIII in the Morning will give the Hour of VIII in the Evening upon the Dial.—On the contrary, the Evening Hour-lines of V and IV, continued thro' the Center, will be the Hour-lines of V and IV in the Morning: and thus all the Hour-lines belonging to ſuch a Dial are drawn.

(9) But ſuppoſing that the Globe you uſe has not the Meridians drawn thro' every 15th Degree of the Equinoctial, you then proceed as follows: Rectify the Globe to the Latitude as before, and bring the Solſtitial Colure to the Brazen-Meridian, where, holding it ſteady, ſet the Hour-Index to the lower XII; then move the Globe till the Index points to the Hour I, and the Colure will interſect the Horizon in 11° 51′ from the Meridian:—Then move the Globe till the Index points to the Hour II, and the Colure will interſect the Horizon in 24° 19′ from the Meridian: And thus the Interſections for every Hour to VI will be found the ſame as in the foregoing Table, by which all the Hour-lines are drawn, as before directed.

(10) Whatever Globe you uſe, this Method of the Colure will be neceſſary for finding the Points of Interſection in the Horizon proper to the Quarters of each Hour; for if you move the Globe ſo that the Index may point to the ſeveral Quarters of each Hour, you will then obſerve the Degrees and Minutes in the Interſection of the Colure with the Horizon: Theſe are to be mark'd in your Circle, and a Ruler laid from the Center thro' each of them will divide each Hour into its proper Quarters, between the Hours of the Dial, on the Border of the Frame reſpectively: and thus is the Horizontal Dial completed, with reſpect to the Hour-lines.

(11.) The next Thing to be done is, to give the Gnomon or Style its proper Height above the Plane, which is that of 51° 30′ for LONDON.

(12.) This Gnomon muſt be placed truly in the Meridian Line of the Dial, with its elevated Part towards the North, and muſt be ſo fixed that it may riſe preciſely from the Center of the Dial, and then the whole is finiſhed.

Prob. LXXIII. *To draw a direct* SOUTH *or* NORTH DIAL, *for any given* Latitude, *or Place, by the* GLOBE only.

Here you proceed by rectifying the Globe to the Latitude of the Place; and fixing the Quadrant of Altitude in the Zenith, you bring it to interſect the Horizon in the true Eaſt Point, to repreſent the prime Vertical of Eaſt and Weſt, which is evidently the Plane of the Dial propoſed.

As this Plane interſects the Plane of the Meridian at right Angles, and ſtands perpendicular on the Horizon, it is very evident, from a bare View of the Globe thus rectified, that the Axis of the Globe contains an Angle with this Plane, which is juſt the Complement of that which it containes with the Horizon, and therefore is juſt equal to the Co-Latitude of the Place, which, for *London*, is 38° 30′

It is farther evident, ſince the Plane of the Dial paſſes through the Center of the Globe, that the ſouthern Part of its Axis is elevated to that Angle on the South Side of this vertical Plane, and that on the North Side the Northern Semi-axis is elevated to the ſame Degree.

Hence, in Caſe of a direct *South Dial* for *London*, the Gnomon muſt be placed in the Meridian Line of the Plane exactly in its Center, and point downward preciſely to the South Pole, in an Angle of 38° 30′ with the Plane.

On the other Side of the Plane, which is the *North Dial*, the Gnomon is elevated to the ſame Height, and points directly to the North Pole, being placed in the Meridian Line, and exactly in the Center of the Plane.

Moreover it is evident, by a bare Inſpection of the Globe, that the Sun cannot come upon the South Side of this vertical Plane before VI o'Clock in the Morning, becauſe it meets with the Hour Circle of VI exactly in the Horizon, and then only on the Equinoctial Days: at all other Times of the Year it will come on the Eaſtern Side of the South Dial after VI, and the ſame may be ſaid with Regard to its ſhining on this Plane after VI in the Evening. Therefore no more than XIII Hour-lines need be drawn on this Plane, *viz.* ſix on each Side of the Meridian.

Again, with reſpect to the North Side of this vertical Plane it is evident, the Sun is upon it from the Time that it riſes to the Time that it comes on this Vertical Plane on the longeſt Day, which is from $\frac{1}{4}$ before IV to about $\frac{1}{2}$ an Hour after VII in the Morning; and in the Evening from $\frac{1}{2}$ an Hour before V to about $\frac{1}{4}$ of an Hour after VIII: And conſequently there will be no Need of drawing more than ten Hour-lines on a direct North Dial in our Latitude, *viz.* five in the Weſt, and five on the Eaſtern Side; but none on the upper, or lower Part of the Dial.

Laſtly, by conſidering the Globe attentively it will appear, that the Meridians, or Hour Circles, fall in a ſimilar Manner upon this prime *Vertical* and *horizontal* Plane, and that, therefore, the Interſections made by them and the vertical Plane, are the ſame with thoſe made between the ſaid Meridian and horizontal Plane, when the Pole is elevated to no more than 38° 30′ in our Latitude. Conſequently, by actually elevating the Pole to that Height, you will have the Points of Interſection given, through which the Points are to be drawn, as in the horizontal Dial before, and are ſuch as are contained in the following Table:

Hours		
12	00	00
1	9	28
2	19	45
3	31	53
4	47	08
5	66	42
6	90	00

Then a Ruler being laid from the Center of the Circle to the Points marked off in the North-eaſt, and North-weſt Quadrants, and Lines drawn quite thro', will give the Poſition of the Hour-lines on both Sides of the Plane at once, thoſe from VI to VI belonging to the South Dial, and the Hours from IV to VIII belonging to the North Side of the Dial.

N. B. The Quarters are here drawn by Means of the Hour Index and Colure, as before directed.

Prob. LXXIV. *To draw the* Hour Lines *upon a* direct South reclining Plane, *by Means of the* Globe.

This Sort of Dials admit of three Varieties; for the Reclination from the Zenith, may be *equal* to, *greater*, or *leſs* than the Diſtance of the Pole from the Zenith.

Variety I. Suppoſe the Plane reclines to the Pole, or juſt 38° 30′ from the Zenith to the Latitude of *London*, then it is evident the Axis of the Earth can have no Elevation above the Plane, but muſt lie in the Plane itſelf and become the Meridian Line thereof.

In order therefore to draw this Dial; on any Point N as a Center, deſcribe a Semicircle A B C, which divide into two Quadrants, A B and B C, by drawing the Line N B, which muſt be continued out to an indefinite Length, *viz.* to O, to repreſent the Hour Line of XII upon the Dial Plane HKLM, whoſe Side H K touches the Semi-circle in the Point B; then divide each Quadrant A B and B C into ſix equal Parts, through which Points of Diviſion lay a Ruler from the Center N, and draw ſtrait Lines to the Plane of the Dial, and they will give the Points in the Side H K, through which, if Lines be drawn parallel to the Meridian Line N O, they will be the Hour Lines on the Dial Plate, as required, which muſt be numbered as you ſee in Fig. 2. of the Plate of Dials.

Then, on the Meridian Line of XII, you muſt fix a Stile, or Plate D F C E, whoſe

Height D F muſt be juſt equal to the Diſtance between the Hour Lines of XII and III, which is juſt equal to the Radius N B; for it is evident, the Line B K is only a Line of Tangents to the Radius N B, and therefore the Diſtance of the Hour Lines III, or IX, muſt be equal to the Tangents of 45° 00′.

On this Dial there cannot be placed conveniently more than nine Hour Lines, the Reaſon of which appears by Inſpection; as that of VII in the Morning and V in the Afternoon would occaſion the Dial to be of a very great Length. The Hours and Quarters may be put into this Dial by ſubdividing the Arches of the Quadrant into Halves and Quarters each.

N. B. This Dial is called the *Equinoctial Dial*, as being peculiar to the People who live under the Line, or have no Latitude.

The *Second Variety* is, when the Reclination is leſs than the Diſtance of the Pole from the Zenith; for Example: Suppoſe the South Plane reclines from the Zenith of *London* 18° 30′, then is the South Pole elevated above this Plane 20° 00′, and a Dial on ſuch a Plane is evidently no other than a South erect Dial in the Latitude of 70° 00′, and therefore may be drawn as before directed, for a direct South Dial.

The *third Variety* is, when the South Plane reclines from the Zenith to a greater Diſtance than the Pole; as for Example: Suppoſe it reclines 71° 30′ from the Zenith of *London*, then will it be 20° below the North Pole, or the ſaid Pole will be elevated 20° 0′ above the Plane; therefore it will be evidently a *Horizontal Dial* in the Latitude of 20° 0′, and may be drawn as before directed in the Problems for Horizontal Dials.

Prob. LXXV. *To draw the* HOUR LINES *on a direct North reclining Plane, by Means of the* GLOBE.

This Problem alſo admits of three Varieties:

For (1.) the Reclination may be equal to that of the *Equinoctial Circle*; or, (2.) it may recline leſs; and, (3.) it may recline more from the Zenith of the given Place.

In the firſt Variety it is evident, the Dial Plane coincides with the Equinoctial Line; conſequently, to draw a Dial on this Plane is no more than to deſcribe a Circle, and divide the ſame into 24 equal Parts; then a Wire being fixed perpendicular to the Plane, in its Center, will then repreſent the Axis of the World, and become the true Stile of this Dial.

N.B. This Dial, 'tis true, is a *Polar Dial*; but it is of Uſe in every Latitude if it be elevated to the *Equator*, or to an Angle equal to the *Co-Latitude*, and placed due North and South: According to the Number of Hours that the Sun can ſhine upon it, ſo many Hour-lines are to be drawn, the reſt being uſeleſs.

In the *ſecond Variety*, the Reclination of the Plane from the Zenith, being leſs than that of the Equinoctial, it is a North erect Dial in ſome Latitude, *viz.* that which is equal to its Diſtance from the Equator. ——— Thus, for Example: Suppoſe the Reclination from the Zenith of *London* were 21° 30′, then it is a direct North Dial in the Latitude of 30° 0′, which is the Diſtance between it and the Equator; and therefore the Hour-lines are drawn as before directed for ſuch Dials.

In the *third Variety* the Plane reclines to a greater Diſtance than the Equator from the Zenith, in which Caſe it evidently becomes an Horizontal Plane in that Latitude which is the Complement of its Diſtance from the Equator. Thus, for Example: Suppoſe it reclines from the Zenith of *London* 71° 30′, then will that be 20° farther than the Equator, and it becomes an Horizontal Plane in the Latitude of 70° 0′, for that is the Elevation of the North Pole above the Plane, as is evident *by rectifying the Globe to that Latitude*, as may be done in every other Caſe of theſe reclining Dials, becauſe the Horizon may be always taken for the Reclining Plane with reſpect to the Zenith of any particular Place, as LONDON in our Examples: And this is mentioned once for all, to avoid frequent Repetitions.

Prob. LXXVI. *To draw the* HOUR-LINES *on any* erect declining Plane, *by Means of the* GLOBE.

Firſt draw an Horizontal Line, as D A B for the upper Part of the Dial Plane, and from the Center A deſcribe the Semi-circle D C B, which divide into two Quadrants D C and C B by a Perpendicular A C, which will repreſent the Meridian of the Plane, or Hour-line of XII, and then let each Quadrant be divided into 90° 0′ reckoned each Way from the Point C. (See Fig. 3. of *Dialling.)*

This being done, rectify the Globe to the Latitude of the Place, *viz. London*, and ſcrew the Quadrant of Altitude to the *Zenith*, *viz.* 51° 30′; then bring the Solſtitial Colure to coincide nicely with the Meridian, and ſet the Hour Index to XII: Laſtly, remove the Quadrant of Altitude to ſuch a Degree from the Eaſt or Weſt Points of the Horizon, towards the North, as is equal to the Plane's Declination. Thus, for Example: If the Plane declines 30° 0′ to the Weſt, the Quadrant of Altitude muſt be fixed 30° 0′ from the Weſt Point towards the North.

This Preparation being made, turn the Globe to the Weſtward till 15° 00′ of the Equator paſs under the Meridian, or the Hour Index points to I in the Afternoon; then will the Colure interſect the Edge of the Quadrant in a Point which ſhews the Number of Degrees, as will give the Diſtance of the Hour-line of I to be ſet off in the Quadrant, from C towards B; then, by revolving the Globe till the Index points to II, the Interſection of the Colure with the Quadrant will give the Number of Degrees from the Meridian, which muſt be ſet off in the Circle from C towards B, for the Hour-line of II. And thus you proceed for the ſeveral Hour-lines for the Afternoon, as long as the Sun can ſhine on ſuch a Plane, which will not be much after VII.

Then moving the Quadrant to the eaſtern Side of the Meridian, place it to 30° 0′ from the Eaſt Point towards the South, and, turning the Globe Eaſtward, place the Index at XI, X, IX, *&c.* Hours exactly, the Interſection of the Colure with the Quadrant at thoſe reſpective Hours will be the Diſtances in Degrees and Minutes, to be ſet off from the Point C toward D in the Circle, by which thoſe Hour-lines, for the Forenoon, may be drawn ſo far as they are required, which will be but to VIII in the Morning.

In ſuch Dials, the Stile ſtands not in the Meridian, or Hour-line of XII, but ſomewhere

where among the Hour-lines of the Afternoon in Weſt Decliners; but *vice verſa*, in thoſe whoſe Declination is Eaſt.

To find the Diſtance of the Sub-ſtile, or Line in which the Style or Gnomon is to be placed, you turn the Globe about 'till the Colure interſects the Horizon at 30° 0′ from the Meridian, and there hold it faſt; then, as in this Caſe the Colure is at right Angles with the Vertical Circle, or Quadrant of Altitude, it will repreſent the Meridian of the Plane, and the braſs Meridian muſt be conſidered as the *Sub-ſtile* of the Plane; therefore the Number of Degrees that is contained in the Quadrant of Altitude between the Colure and the Zenith, which you will find to be 21° 40′, is the Diſtance of the Sub-ſtile from the Meridian Line, AC; which, therefore, ſet off in the Circle BCD from C to E, will give the Diſtance of the Sub-ſtile or Line AG from the Meridian of the Dial AC.

Then, to find the Height of the Pole, or Gnomon, above the Plane of the Dial, you count the Number of Degrees on the Colure between the Vertical Circle and the Pole, which you will find to be 32° 36′; therefore from the Point E, where the Sub-ſtile croſſes the Circle, ſet off 32° 36′ to H, through which Point draw AF for the Gnomon of the Dial: And thus is the Dial compleated. And after this Manner may any Dial be drawn, declining any Number of Degrees towards the Eaſt.

But when the Dials decline juſt to the *Eaſt* or *Weſt Points*, or when their Plane coincides with the Plane of the Meridian, then the Pole has no Elevation on ſuch a Plane, and the Axis of the World becomes now the Hour-line of VI; and the other Hour-lines are drawn by deſcribing a Semi-circle and dividing it into 12 equal Parts, as before directed for Equinoctial Dials; and the Gnomon, or Stile, is, in theſe, placed perpendicularly on the Hour-line of VI, as it is there on the Hour-line of XII; and the Height of the Stile is here equal to the Diſtance of the Hour-line of IX or III, from the Hour-line of VI, or to the Radius of the Circle: And thus are theſe *direct* EAST and WEST DIALS conſtructed, in the ſame Manner with the *Equinoctial Dials*.

I might next proceed to ſhew how Dials, both declining and reclining, may be made by the Globes: But as they are ſeldom required, and the Apparatus to the Globe for this Purpoſe will require an additional Semicircle, it will ſcarcely be worth while to attempt it in this Way. However, by Means of the Globes the *Rationale* even of this Sort of Dials will be beſt of all explained and comprehended, which will be a Matter of no great Difficulty, if what we have ſaid in regard to other Dials be but well underſtood.

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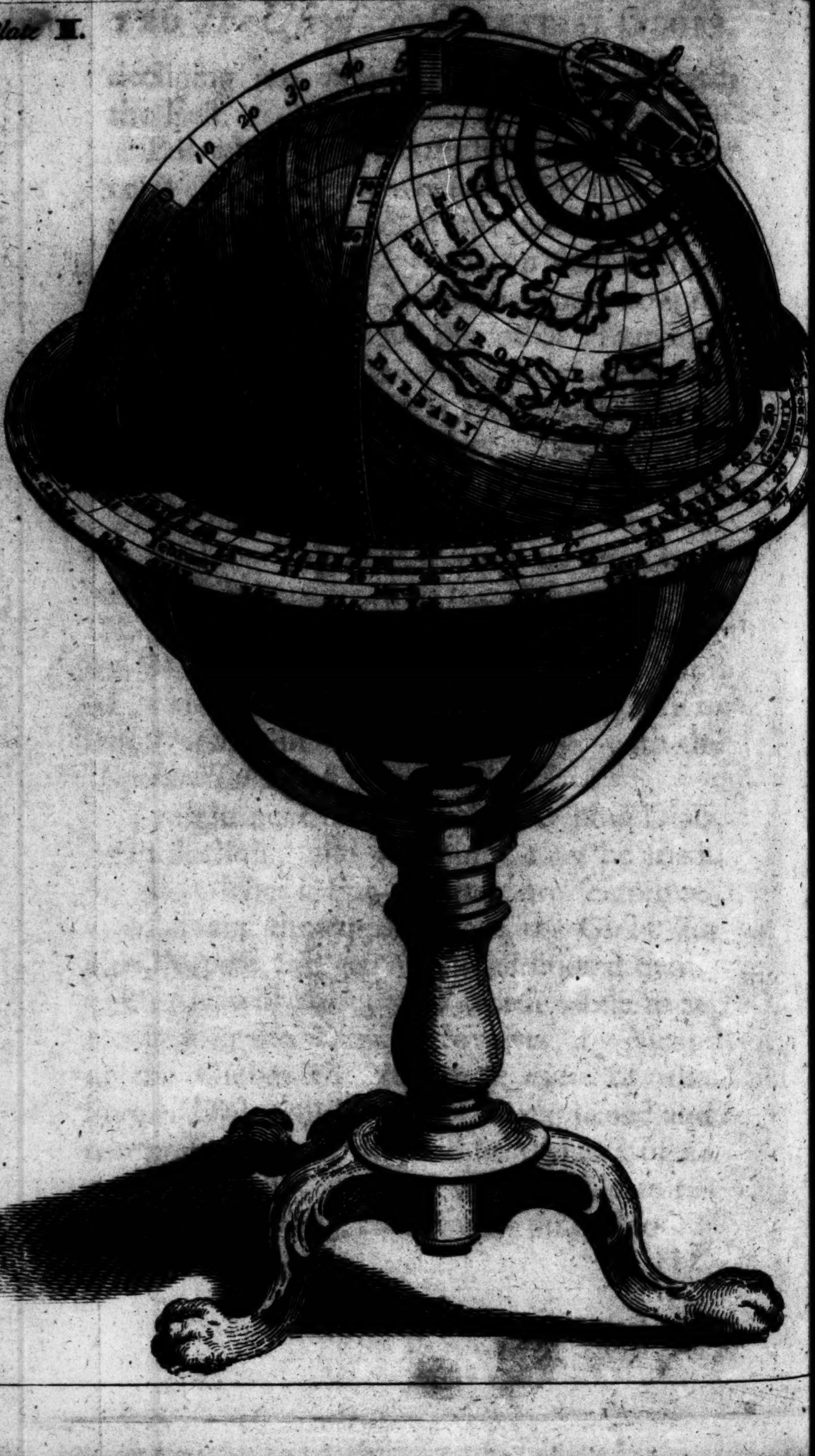
The TERRESTRIAL GLOBE.

Plate II.



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THE USE OF THE TERRESTRIAL GLOBE.

PART II.

Chap. I.

The Solution *of* Geographical Problems *by the* Terreſtrial Globe.

Prob. I.

TO find any particular Place *on the Globe, from a Table of given* Latitudes *and* Longitudes.

Bring the Degree and Minute of Longitude to the Meridian, and look for the given Latitude, whether North or South, on the ſaid Meridian, and juſt under it will be the Place required. For Example, let it be required to find LONDON whoſe Longitude is 0′, and Latitude 51° 30′; then ſuppoſing the firſt Meridian of Longitude, in the Table, to paſs through *London*, and uſing Mr. *Senex*'s Globe of 12 Inches Diameter, bring the Beginning or 0° of Longitude, (which you will find on the under Side of the Equator,) to the Meridian, and exactly under 51° 30′ on the Meridian, you will ſee the City of *London* on the Globe.

Again: Suppoſe, in the Table, you find the Longitude of *Conſtantinople* to be 28° 55′, and the Latitude 41° 6′; then, bring 28° 55′ of the Equator to the Meridian, and under 41° 6′ on the North Part of the Meridian, you will obſerve the City of *Conſtantinople* on the Globe.

Prob. II. *To find the* LATITUDE *and* LONGITUDE *of any Place obſerved on the Surface of the Globe.*

Let the given Place be *Conſtantinople*, then, turning the Globe about, bring that City to lie under the Meridian, and you will obſerve the Degree juſt over it to be 41° 6′ N. Latitude: Then, without moving the Globe, obſerve the Degree on the under Side of the Equator cut by the Meridian, and you will find it to be 28° 55′.

Again: Let the given Place be *Port Royal* in *Jamaica*, which bring to the brazen Meridian, and you will find it to lie under the 18° of North Latitude, and 77° of Weſt Longitude.

N. B. By this Problem the Difference of Latitude and Difference of Longitude between any two Places are given. Thus the Difference of Latitude between *London* and *Conſtantinople* is 10° 24′; and the Difference of Longitude between *Conſtantinople* and *Port Royal* in *Jamaica* is found to be 105° 55′.

Prob. III. *To find all thoſe* PLACES *of the ſame* LATITUDE *and* LONGITUDE *with thoſe of any given* PLACE.

Bring the given Place to the Meridian, then all thoſe Places which lie under the Meridian have the ſame Longitude with the given Place; and, turning the Globe on its Axis, you will obſerve all thoſe Places which paſs under the ſame Degree of the Meridian with the given Place, will have the ſame Latitude with it.

Prob. IV. *To find the* DISTANCE *between any two Places on the Globe in* Engliſh MILES.

Bring one of thoſe Places to the Meridian, then, if the other Place lies under the Meridian alſo, the Diſtance between them will eaſily appear in Degrees of the Meridian; but if the other Place is not under the Meridian, fix a Quadrant of Altitude over one Place upon the Meridian, and then bring it to lie over the other given Place, and the Difference between them, in Degrees of a great Circle, will be ſhewn on the Edge of the Quadrant, which, multiplied by the Number $69\frac{1}{2}$, will give the Diſtance in *Engliſh* Miles: Thus the Diſtance between *London* and *Rome* will be found to be about 13°, which reduced, will give $903\frac{1}{2}$ *Engliſh Miles*, or 780 *Geographical Miles*, reckoning 60 to a Degree.

Prob. V. *To find all thoſe* Places *that are at the ſame or equal Diſtance from any given Place, as* London, *for Inſtance.*

Bring the given Place, or *London*, to the Meridian, and fix the Quadrant of Altitude preciſely over it, then turning the Quadrant about upon the Surface of the Globe, you will obſerve all thoſe Places over which the ſame, or a given Degree of the Quadrant, paſſes, and they will be all equidiſtant from *London*; for, by this Means, the Parallels of equal Diſtance will be deſcribed from the Zenith to the Horizon.

Prob. VI. *To find the* Angle *of* Position, *or the* Bearing *of any one Place from another given, as* London, *for Inſtance.*

Rectify the Globe for the Latitude and Zenith of one of the given Places, *viz.* *London*, and fix the Quadrant of Altitude over it; then bring the ſaid Quadrant to lie over the other given Place, and it will ſhew, in the Horizon, the Point of the Compaſs on which it bears from *London*; and the Angle, which is contained between the Quadrant of Altitude and the Meridian, is called the *Angle of Poſition:* Thus let the two given Places be *London* and *Port Royal* in *Jamaica*; then, by rectifying the Globe for the City of *London*, let the Quadrant of Altitude be laid upon *Port Royal*, and it will cut the Horizon in the Weſtern Point very nearly, and thereby ſhews that *Port Royal* bears Weſt from *London*.

But if the Globe be rectified for *Port Royal*, and the Quadrant of Altitude be laid over the City of *London*, it will cut the Horizon in about 40° 30′ from the North Point Eaſtward, which ſhews that *London* bears nearly North-eaſt from *Port Royal*, or the Angle of Poſition is 40° 30′ from the North towards the Eaſt.

Hence it appears, that the *geographical Bearing* of Places is very different from a *Bearing* taken in a *Nautical Senſe*; for, with Navigators, if one Place A bears Weſt from another Place B, the Place B will bear Eaſt from the Place A: In order to which they muſt be both in the ſame Parallel.

And again, if one Place A bears North-Eaſt from another Place B, the ſame Place B will bear South-weſt from the Place A, as being both on the ſame *Rhumb* or Curve, which cuts every Meridian under the ſame Angle; but neither of thoſe Caſes can be true in a Geographical Senſe, as appears from the two Places of *London* and *Port Royal* in the above Problem.

Prob. VII. *When it is* NOON *in a given Place, to find what Hour of the Day it is at any other Place propoſed.*

Bring the given Place to the Meridian, and ſet the Hour-Index to the upper XII, then turn the Globe about till the Place propoſed comes to the Meridian, and the Index will point to the Hour required.

Let the Example be for *London* and *Pekin* in *China*: Then placing *London* under the Meridian, and the Index to XII, you revolve the Globe and bring the City of *Pekin* to the Meridian, when the Index will point to 40′ after VII in the Evening, when it is Noon with us.

But if the Place propoſed has Weſt Longitude from *London*, as *Jamaica*, for Inſtance: Then turn the Globe Eaſtward 'till *Port Royal* comes under the Meridian, and the Index will Point to about 45′ after VI in the Morning, the Hour of the Day with them, when Noon with us.

Prob. VIII. *To find all thoſe* PLACES *where it is* NOON *at any* given Hour *of the Day, at a given* PLACE.

Bring the given Place to the Meridian, ſet the Index to the given Hour, then turn the Globe about till the ſaid Index points to the upper XII: Then obſerve all thoſe Places which lie under the braſs Meridian, for to them it is Noon at that Time.

For Example: Let *London* be the given Place; and let it be required to find all thoſe Places where it is Noon when it is ½ an Hour after VII in the Morning at *London:* Then proceeding as above directed, you will find the braſs Meridian lie over *Muſcovy* in *Aſia* and Part of the Mogul's Empire, in all which Places it is Noon at that Time. By the ſame Method it will be found, that when it is IV o'Clock in the Afternoon with us, it will be Noon at *Martinico*, *Antigua*, and other of the Windward Iſlands; alſo at *Louiſbourg* in *North America*, and over all the Middle Part of *South America*.

Prob. IX. *For any* GIVEN HOUR *of the Day in the Place where you are, to find the* HOUR *of the Day in any other* PLACE *propoſed.*

Bring the Place where you are to the Meridian, and ſet the Index to the given Hour, then turn the Globe 'till the Place propoſed comes to the Meridian, and the Index will ſhew the Hour of the Day there, as required.

Thus, for Example: When it is IV o'Clock in the Afternoon with us, it is $\frac{3}{4}$ after XI at Night at the City of *Pekin* in *China*.

Prob. X. *At a* given Hour *at a given* Place, *to find all thoſe* Places *where it is any other given* Hour *of the Day*.

Bring the given Place to the Meridian, and ſet the Index to the given Hour, then revolve the Globe till the Index points to the other given Hour: Then all thoſe Places which lie under the Meridian have that Hour of the Day. This Problem is ſo plain as to need no Example.

Prob. XI. *To find all thoſe Places to which the* Sun *is* Vertical *for any given Day*.

Bring the Sun's Place for the given Day to the Meridian, and obſerve the Degree that it cuts: Then turn the Globe quite round, and all thoſe Places that paſs under the ſame Degree of the Meridian are thoſe required, or to whom the Sun will be vertical for that Day.

Thus, for Example: On the 10th of *May*, when the Sun's Declination is 17° 30′, all thoſe People who live under that Parallel of North Latitude have the Sun in their Zenith that Day at Noon, who are the *Aſkii*, or ſhadowleſs: Amongſt theſe you will find the Inhabitants of *Porto Rico*, *Hiſpaniola*, *Jamaica*, *&c.* in the Weſtern Hemiſphere; the Midland Parts of *Africa*, the Southern Part of the *Mogul*'s Empire, and the Kingdom of *Pegu* in the farther *India*.

Prob. XII. *To find* what Day *of the Year the* Sun *will be* vertical *in the Torrid Zone to any given* Place.

Bring the given Place to the Meridian, and mark the Degree exactly over it, then turn the Globe round and obſerve the two Points of the Ecliptic which paſs under that Degree of the Meridian; Laſtly, ſee on the wooden Horizon on what Day of the Year the Sun is in thoſe Points of the Ecliptic, for thoſe are the Days required.

For Example: Let the given Place be *Jamaica*, which bring to the Meridian, and obſerve the Degree under which it lies; then, revolving the Globe, the two Points of the Ecliptic which paſſes under the ſame Degree of the Meridian will be the 20° of *Taurus*, and 10° of *Leo*, and therefore the two Days in which the Sun poſſeſſes thoſe two Degrees of the Ecliptic will be the 9th of *May* and the 2d of *Auguſt*, which will be the two *Mid-ſummer* Days to the People of that Iſland.

Prob. XIII. *To find thoſe* PLACES *in the North Frigid* ZONE *where the Sun* begins *to* ſhine *conſtantly, without ſetting, on any given Day between the* vernal EQUINOX *and* MIDSUMMER.

Find the Sun's Place in the Ecliptic for the given Day, bring it to the general Meridian, and obſerve the Degrees of Declination; then all thoſe Places which are the ſame Number of Degrees diſtant from the Pole are the Places required to be found.

Thus, for Example: On the 10th of *May* the Sun's Declination is 17° 30′, which deducted from 90°, the Remainder is 72° 30′: Therefore all thoſe Places whoſe Latitude is equal to 72° 30′ will have the Sun in the Northern Part of the Horizon at XII o'Clock at Night.———The Reaſon of all which is evident by a bare Inſpection of the Globe, rectified to the Latitude 72° 30′.

Prob. XIV. *To find on what* DAY *the* SUN *begins to* ſhine *conſtantly, without* ſetting, *in any given* Place *in the North Frigid* ZONE, *and how long.*

Rectify the Globe to the Latitude of the Place, and, turning it about, obſerve what Points of the Ecliptic between *Aries* and *Cancer* cut the North Point of the Horizon; then find, by the Calendar, (on the Horizon,) on what Days the Sun will enter thoſe Degrees of the Ecliptic, and they will ſatisfy the Problem.

Thus, for Example: Rectify the Globe for the Midland Parts of *Nova Zembla*, whoſe Latitude is 74°, and then turning the Globe about its Axis, you will ſee the 15° of *Taurus* and the ſame Degree of *Leo* both touch the North Point of the Horizon; therefore, on the 4th of *May* the Sun begins to ſhine without ſetting, and ſo continues till the 8th of *Auguſt* following:—— At the ſame Time it appears, that in this very Place, when the Sun has more than 16° of *South* Declination, it ceaſes to riſe above their Horizon, in the Winter Half of their Year, and continues juſt as long *inviſible*.

Prob. XV. *To find the* PLACE, *or Part of the* SURFACE *of the Terraqueous* GLOBE, *over which the Sun is vertical on any* given DAY, HOUR, *and* MINUTE.

Find the Sun's Place and Declination for the given Moment of Time: Then find (by Prob. VIII.) thoſe Places which have the Sun on the Meridian at that Time; and, among them, that which paſſes under the given Degree of Declination is the Place deſired, or that in whoſe Zenith the Sun then is.

Thus, for Example: On the 10th of *May* at VIII o'Clock in the Morning, admit the Sun's Declination be 17° 30′, then, proceeding as above directed, we ſhall find it to be Noon in all thoſe Places from the Middle of *Nova Zembla* to the Middle of the Southern Part of the *Perſian* Empire, and, amongſt them, that Part which is exactly under the Degree of the Sun's Declination is a Point of the *Arabian* Sea, over which the Sun is vertical at the given Time.

Prob. XVI. *To find, for any given* DAY *and Hour, thoſe* PLACES *wherein the Sun is then* riſing *or* ſetting, *or on the* Meridian; *alſo thoſe Places which are* enlightened, *and thoſe which* are not.

Find the Place to which the Sun is vertical at the given Time, and bring the ſame to the Meridian, and elevate the Pole to the Latitude of the Place, then all thoſe Places which are in the Weſtern Semi-circle of the Horizon have the Sun riſing; and thoſe in the Eaſtern Semi-circle ſee it ſetting: And to thoſe under the Meridian it is Noon. Laſtly, all Places above the Horizon are enlightened, and all below are in Darkneſs, or Night.

Thus, for Example: Let the Place be that Part of the *Arabian* Sea which was found in the laſt Problem, to which the Sun is vertical on the 10th of *May* at VIII in the Morning, and having rectified the Globe for that Place, (which is always equal to the Sun's Declination,) bring the ſaid Place to the Meridian, and there let the Globe reſt: Then it is evident, that all thoſe Places that lie under the Meridian have their Noon Day: Then all thoſe Parts of the Earth, lying under the Weſtern Semi-circle of the Horizon, will ſee the Sun riſing, as they are all of them at 90° diſtance from it; and the Motion of the Globe carrying them towards the Sun, he will appear to riſe gradually above their Horizon.——— On the Contrary, thoſe Parts of the Globe under the Eaſtern Semi-circle of the Horizon, being alſo every where 90° diſtant from the Sun, will ſee him ſetting, being carried by the Motion of the Globe out of the enlightened, into the dark, or nether Hemiſphere.

Prob. XVII. *The Day and Hour of an* ECLIPSE *of the* SUN *or* MOON, *or* TRANSIT *of the* PLANETS *or other Phænomenon in the Heavens being given, to find all thoſe Places on the Surface of the Globe, where the* Beginning, Middle, *or* End *thereof will be viſible.*

Find the Place to which the Sun is vertical at the given Inſtant, at the Beginning, Middle, or End of the Tranſit or Eclipſe: Then will thoſe Phaſes be viſible at all thoſe

Places

Places which are above the Horizon at thoſe Inſtants of Time.

We ſhall examplify this curious Problem by the late moſt remarkable TRANSIT of *Venus* over the Sun, *viz.* on the 6th of *June*, 1761.

The BEGINNING of this TRANSIT was about 5′ after II o'Clock in the Morning, the Place of the Sun in 15° 30′ of *Gemini*, and its Declination 22°. Then rectify the Globe to a Latitude equal to the Sun's Declination, *viz.* 22°; bring the given Place of Obſervation, *London*, for Inſtance, to the Meridian; and place the Hour Index to 5′ after II in the Morning: Then turn the Globe about till the Index points to XII at Noon, and the Place under the 22° of the Meridian will be that to which the Sun is vertical at the Time that the Planet *Venus* appears to touch his Eaſtern Limb; and therefore all that Hemiſphere which is illuminated by the Sun, or above the Horizon, will ſhew thoſe Places of the Earth where the Beginning of the Tranſit is viſible. Thus the People in all thoſe Parts which lie under the Meridian will ſee the Beginning of the Tranſit juſt at Noon:—All thoſe Places which lie in the Weſtern Part of the Horizon will ſee the Beginning of the Tranſit at Sun-riſing:———And thoſe Parts of the Earth which lie under the Eaſtern Semi-circle of the Horizon, ſee the Beginning at Sun-ſet.

From whence it appears, that the Beginning of the Tranſit was ſeen in the Forenoon by the vaſt Continent of *Aſia*, a ſmall Part of *Arabia* in *Africa*, and the North-Eaſt Parts of *Europe*; but not in *Great-Britain*.

The MIDDLE of the TRANSIT happening at about ½ an Hour after V in the Morning, the City of *London* muſt be again brought to the Meridian, and the Index placed to ½ after V; then turn the Globe about 'till the Index points to the upper XII, and there let it reſt. ——The Part of the Earth's Surface which is now under the 22° of the Meridian, *viz.* a Part of the *Indies*, Eaſtward of *Bengall*, will then obſerve the Sun in their Zenith; and all the Parts of the World which lie under the diurnal Meridian are thoſe which ſee the Middle of the Tranſit at Noon:— Thoſe in the Weſtern Part of the Horizon view it at Sun-riſing, and thoſe in the Eaſtern Part at Sun-ſet.——From whence it appears, that all *Europe*, almoſt all *Africa*, and Half the Continent of *Aſia* ſaw the Middle of the Tranſit in the Forenoon, and the Eaſtern Part of *Aſia* viewed it in the Afternoon.

Laſtly, for the END of the TRANSIT, bring *London* to the Meridian, and ſet the Hour Index to 20′ after VIII, and turn the Globe till it points to XII: Then will nearly the Middle Part of the *Red Sea* be that to which the Sun is vertical at the Egreſs of *Venus*,

Venus, and all the Parts lying under the Meridian will ſee her go off from the Sun's Diſk at Noon.———In the Weſtern Parts of the Horizon, the Countries appear where the Tranſit is ſeen to end at Sun-riſing.—Theſe are a few of the moſt Eaſterly Parts of North and South *America*:———The Countries lying under the Eaſtern Semicircle ſee the End of the Tranſit at Sunſet:———All *Africa* and *Europe* obſerved this Phaſes in the Forenoon, and all *Aſia* in the Afternoon.———Upon the whole it appears, that this extraordinary Phænomenon was almoſt wholly inviſible to the Continent of *America*; but it will be their Turn to have their Curioſity ſatisfied, in this Reſpect, by the next Tranſit of the ſame Planet, which will happen in the Year 1769, and which will be as little ſeen and obſerved by us. After the ſame Manner, it may be ſhewn where the Beginning, Middle, or End of any *Eclipſe* will be viſible, or not ſo.

Prob. XVIII. *To find in what* LATITUDE *the* longeſt DAY *is of a given Length.*

Bring the ſolſtitial Points to the Meridian, and ſet the Index to XII at Noon, then turn the Globe Weſtward till the Index points at Half the Number of Hours given, which being done keep the Globe from turning round its Axis, and ſlide the Meridian

dian up or down in the Notches till the ſolſtitial Point comes to the Horizon: Then that Elevation of the Pole will be the Latitude.

For Example: Suppoſe the Latitude be required in which the Day is 14 Hours; by proceeding as above directed, the Latitude will be found near the Parallel of 40°, and for the longeſt Day of 20 Hours the Latitude will be ſomething more than 63°.

Prob. XIX. *To exhibit a general Repreſentation of the Lengths of* DAYS *and* NIGHTS *throughout the Year, in any given Latitude.*

Elevate the Globe to the given Latitude, and bring the Solſtice to the Meridian, where let it reſt: Then will the Parallels of North Latitude, from the Equator to the Tropic of *Cancer*, repreſent the diurnal Arches, or Length of Days in the Summer Half Year, from the Mean Day when the Sun is in the Equator, to the longeſt Day, which is repreſented by the Tropic itſelf. Then, for the Winter Half Year, the ſame Parallels of Latitude above the Horizon do repreſent the decreaſing Length of Days, from the Mean Day in the Equator, to the ſhorteſt in the Tropic of *Capricorn*.——— Indeed nothing can be more amuſing or inſtructive, than to ſhew how inſtantaneouſly, by the Globe, all the Variety of different

Lengths of Days and Nights, for every Part of the Year and for every Latitude of Place, are repreſented to the View by a Motion of the Brazen Meridian up and down in the Notches of the Horizon :——It gives us a tranſient, and, as it were, ſimultaneous View of all the Phænomena and Viciſſitudes of all the Seaſons in the whole Year and throughout the whole World, at once, and in every different Poſition of the Globe.

Prob. XX. *To find thoſe* INHABITANTS *of the Earth called the* PERIOECI *with reſpect to* LONDON.

Bring *London* to the Meridian and ſet the Hour Index to the upper XII, then turn the Globe about till the Index points to the lower XII, and that Part of the Globe under 51° 30′ of the upper Meridian, is that required, which, being the Northern Part of the great *Pacific Ocean*, it appears there are no Inhabitants of that Denomination with Reſpect to *London* ; but the greateſt Part of *China* in *Aſia*, and the *Gulph* of *Mexico* in *America*, or what is uſually called the *Weſt Indies* are very nearly *Periœci*, to each other.

Prob. XXI. *To find thoſe* INHABITANTS *of the Earth called* ANTOECI.

Theſe are found by counting equal Degrees of Latitude from the Equator upon the Meridian on either Side.

Thus, for Example: *Tripoli*, on the Northern Coaſt of *Africa*, and the *Cape of Good Hope*, on the Southern Point, lie nearly in the ſame Parallel of Latitude, and under the ſame Meridian in the Equator are *Antœci* to each other, having the ſame Length of Days, and Nights, and the ſame Viciſſitudes of Seaſons; but at oppoſite Times of the Year.

Prob. XXII. *To find the* ANTIPODES *to any given Place, as* LONDON, *for Inſtance.*

Bring *London* to the upper or diurnal Semi-circle of the Meridian, then, in the nether Semi-circle of the Meridian, reckon the ſame Number of Degrees Southward from the Equator as is equal to the North Latitude of *London*, *viz.* 51° 30′; the Point of the Globe lying under this Degree of the lower Meridian, is that diametrically oppoſite to *London*, and therefore they are *Antipodes* to each other: But, it appears to be either a Part of the unknown Lands of *New Zealand*, or elſe a Part of the Southern Ocean; therefore our *Antipodes* are not known; but the Midland Parts of *Tartary* and Southern Parts of *America*, called *Terra Magellanica*, are *Antipodes* to each other, as is eaſily ſeen by the Globe.

Prob. XXIII. *To find thoſe* PLACES *in the* Torrid Zone, *to whom the Sun will appear* twice *in the* Forenoon *or* Afternoon *upon the ſame* AZIMUTH.

Let the Sun be in the Beginning of *Cancer* on the longeſt Day, and then there are many Latitudes in the Torrid Zone in which this Phænomenon may be obſerved. Thus if we take the Latitude of *Jamaica* 18°, and rectify the Globe thereto, the Quadrant of Altitude will in one certain Azimuth touch the Parallel, or Tropic of *Cancer*; but if removed a little more Northward, it will cut the ſaid Parallel in two Points, and continue to do ſo till it coincides with the ſaid Parallel in the Horizon: Therefore bring the Beginning of *Cancer* to the Meridian, and ſet the Hour-Index to XII, then turn the Globe about till the Beginning of *Cancer* be in the Eaſtern Horizon, and the Hour-Index will point to ¼ after V, which is the Time of Sun-riſing in that Latitude on their longeſt Day.——Again, place the Quadrant of Altitude to that Part of the Horizon where the Ortive Amplitude is 65° from the North, and is the Azimuth in which the Sun riſes for that Morning, as the Sun advances it will gain Azimuths more and more Southward.

Thus, for Example: At VII o'Clock it will be nearly upon the Azimuth of 70° from the North, at VIII o'Clock it will be on the Azimuth of 72°, and about 40′ after

VIII it will attain its moſt Southern Azimuth, which is about 73°, at the Altitude of about 46° above the Horizon: On this Azimuth it will appear for ſome Time, *viz.* till about IX o'Clock, and at the Altitude of 50° it will begin to go off upon Azimuths more and more Northern. Thus at X o'Clock it will be again upon the Azimuth of 72° from the North, at ½ after X it will be upon the Azimuth of 69°, at 50′ after X it will again get upon the Azimuth equal to the Amplitude, and then proceed through all leſs Degrees of Azimuths to the North.

N. B. In this Method of ſolving this very curious Problem, the *Rationale* of this odd Phænomenon will more plainly appear, as alſo the Reaſon why it can be ſeen only by the Inhabitants of the Torrid Zone, and moſt evidently to thoſe between 15 and 20° of Latitude.——It may be farther obſerved, that this very Problem is a remarkable Caſe of the Ambiguity of ſpherical Triangles, ſince, in a given Latitude, Declination, and Azimuth of the Sun, if the Hour of the Day be required, it is very evident from hence there may be two Anſwers given, and it will be uncertain which is the right, unleſs from ſome particular Conditions of the Problem.

Prob. XXIV. *To find all thoſe Places of the Earth where an* ECLIPSE *of* JUPITER'S SATELLITES *will be viſible.*

We have already ſhewn when *Jupiter* may be ſeen in any particular Place, or Latitude; but it may be neceſſary, on many Accounts, to give a more general Solution to this Problem, and to ſhew how, by the Globe, it will be eaſy to know all thoſe Places of the Earth's Surface where Eclipſes of *Jupiter*'s Moons may be obſerved at any Time of the Year, which will be very uſeful to *Navigators*, *Aſtronomers*, *&c.*

If *Jupiter* be in *Conſequentia*, or follows the Sun, and ſets after him in the Evening, then proceed thus: Find that Part of the Earth's Surface to which the Sun is vertical, and rectifying the Globe to the Sun's Declination, bring that Point to the Meridian which will then be in the Zenith, holding the Globe faſt in this Poſition, with a Black-lead Pencil draw a Line on the Surface of the Globe, along the Eaſtern Semi-circle of the Horizon, and that will denote all thoſe Places to whoſe Inhabitants the Sun is ſetting at that Time, as we have ſhewn in the foregoing Problems.

Then find *Jupiter*'s Place in the Ecliptic, and rectify the Globe to his Declination, by making his Place the Zenith, as before, for the Sun, and draw a Line along the Surface of the Globe by the Eaſtern Semi-circle of the Horizon, and it will likewiſe denote all thoſe Places where *Jupiter* will appear ſetting: Therefore, the Space of the Earth's

Surface between theſe two Lines will be that in which *Jupiter* will be viſible after Sunſet, and conſequently where the Eclipſes of his Moons may be obſerved.

In the ſame Manner, if *Jupiter* be in *Antecedentia*, or riſes before the Sun, you proceed as before to bring *Jupiter* and the Sun ſeverally to the Zenith, and drawing a Line by the Weſtern Semi-circle of the Horizon in each Caſe, then the Space included between theſe Lines will be all that Space of the Earth's Surface in which *Jupiter* may be ſeen before Sun-riſing.

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CHAP. II.

The USE *of the* ANALEMMA *on the* Terreſtrial GLOBE.

THE *Analemma* is a ſmall Slip of Paper, paſted on the Surface of all Mr. *Senex*'s Terreſtrial Globes; the Length of it is juſt equal to the Breadth of the Torrid *Zone*, or Diſtance between the two Tropics. It contains the CALENDAR of *Months* and *Days* in two Parts, beginning from the Day of the Winter Solſtice, and proceeding to that of the Summer Solſtice on one Part, and from thence it returns again to the Winter Solſtice. The Months and Days are ſo laid down and divided as to correſpond exactly with the Declinations North or Eaſt, which the Sun has on each reſpective Day through the Year. —— This will evidently appear if the ſaid *Analemma* be brought to lie under the brazen Meridian, and from thence the following Problems may be eaſily deduced.

Prob. XXV. *To find the* SUN'S DECLINATION *on any Day of the Year, by the* ANALEMMA, *without knowing its Place.*

Bring the *Analemma* to the Meridian, and thereon, over the given Day of the Month, the Sun's Declination will be ſeen.

Prob. XXVI. *To find by the* ANALEMMA *the* SUN'S PLACE *in the Ecliptic, and* RIGHT ASCENSION, *for any given Day of the Year.*

Bring the Analemma to the Meridian and hold a Pin or Wire againſt it over the given Day; then turn the Globe about 'till a Point of the Ecliptic comes under the Wire, which will ſhew the Sun's Place in that Quarter of the Ecliptic which correſponds to the Quarter of the Calendar in which the given Day is. Its *right Aſcenſion* is ſhewn in the Equinoctial Line, at the ſame Time.

23
15
115
23
345

Prob. XXVII. *To find by the* ANALEMMA *the Time of the* SUN'S RISING *and* SETTING, *with its* AMPLITUDE, *for every Day in the Year by Inſpection, in a given* LATITUDE.

Rectify the Globe for the given Latitude of the Place, and bringing the middle Part of the *Analemma* to the Meridian, ſet the Hour-Index to XII, then turn the Globe about to the Eaſt 'till the moſt Southern Part of the *Analemma* coincides with the Horizon, then will the Index point to about ¼ after

VIII in the Morning for the Time of Sun-riſing on the ſhorteſt Day.—Then bring any other Day between the 20th of *January* and the 20th of *March*, to the Horizon, and the Index will ſhew the Time of the Sun's riſing for that Day.—Alſo from the 20th of *March* to the 20th of *June*, any given Day of the ANALEMMA being brought to the Horizon, the Index will ſhew the Time of its riſing on that Day alſo:—Conſequently, the Time of the Sun-riſing and Sun-ſetting, from one End of the ſix Months to the other, is ſeen for every Day reſpectively, by the Motion of the *Analemma* through the various Parts of the Horizon; and its Amplitude for every Day is ſhewn by Inſpection, from 38° of South Amplitude to 38° of North.——And all that has been ſaid about its *riſing* is the ſame with regard to its *ſetting*. By this Means a general Idea may be formed, as it were, inſtantaneouſly, of the various Length of Days and Nights throughout the Year.

Prob. XXVIII. *To find, by the* ANALEMMA, *the Sun's* ALTITUDE *and* AZIMUTH, *for any given* DAY *and* HOUR.

Rectify the Globe for the Latitude and for the *Analemma*, then turn the Globe 'till the Index points to the given Hour, and bring the Quadrant of Altitude to lie over the given Day of the Month, and that Day will ſhew, on the Edge of the Quadrant, the Altitude of the Sun is ſeen; and, in the Horizon, the Azimuth is ſhewn by the Quadrant from the South, or North, Points.

For Example: on the 10th of *April* at IX in the Morning, the Sun's Altitude is found about 33° 30′, and its Azimuth 56° from the South.

Prob. XXIX. *At a given Hour in the Morning, or Afternoon, to find all the different* ALTITUDES *and* AZIMUTHS *the* SUN *can have for every* DAY *in the* YEAR.

Rectify the Globe to the Latitude and *Analemma*, then revolve the Globe till the Index points to the given Hour, and there keep it ſteady; then bring the Quadrant of Altitude to lie over the Southern Part of the *Analemma*, and it will ſhew the Sun's Altitude and Azimuth on the ſhorteſt Day of the Year at a given Hour: Then removing the Quadrant of Altitude gradually over all the Length of the *Analemma* till it comes upon the Northern Part, and there the greateſt Altitude and Azimuth will appear on the Edge of the Quadrant in the *Analemma* and Horizon.

For Example: Let the Hour given be IX in the Morning, then will the Altitude on the ſhorteſt Day be 4° only, and the Azimuth 44°; and on the longeſt Day the Altitude will be 43°, and the Azimuth; 73°; ſo that the Altitude will vary at that Hour no leſs than 39°, and the Amplitude 29°.

Prob. XXX. *To find all the different Times of the* DAY, *throughout the* YEAR, *on which the* SUN *will be upon a given* AZIMUTH, *and its Altitude for thoſe Times on every* DAY *reſpectively.*

Let the given Azimuth be that of 45° or South-Eaſt, and the Globe being rectified for the Latitude and *Analemma*, bring the Quadrant of Altitude to the given Azimuth; then move the Globe about till the Southern Part of the *Analemma* comes to the Edge of the Quadrant, then will the Time be ſhewn, by the Index, when the Sun comes to the given Azimuth on the ſhorteſt Day, and is a little before IX in the Morning, with an Altitude of little more than 3°: Then revolve the Globe Weſtward till the moſt Northern Part of the *Analemma* touch the Edge of the Quadrant, (remaining ſtill in the given Azimuth,) then will the Index ſhew the Time in which the Sun is upon that Azimuth on the longeſt Day, which will be about 35′ after X, and the Altitude then will appear to be 55° 30′: —— The Time of it's being on that Azimuth for any intermediate Day, and it's Height at that Time, will appear by ſtoping the Globe when the given Day comes to the Edge of the Quadrant.

Prob. XXXI. *From the obſerved Altitude of the* SUN, *to find the* HOUR *and* AZIMUTH *in a given Latitude by the* ANALEMMA.

Having rectified the Globe, as before directed, move the Globe and Quadrant of *Altitude* ſo together that the given Day of the Month may coincide with the given Degree of *Altitude* on the Edge of the Quadrant.

Thus, for Example: Suppoſe, on the 20th of *April* in the Morning, you obſerve the Sun's Altitude 25°, then proceeding as directed, you will find the Index point to VIII in the Morning for the Time required, and the Quadrant will cut the Horizon in 77° 30′ for the *Azimuth* at that Time.

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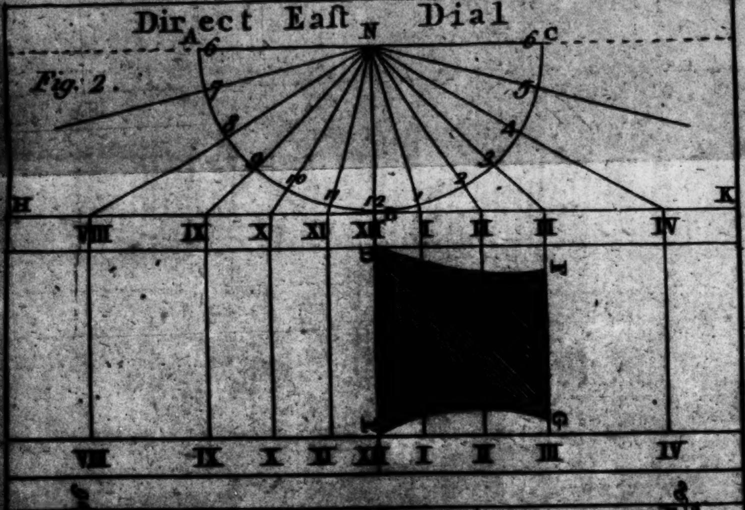
CHAP. III.

Of the Use *of the* Terreſtrial Globe *in* Navigation.

AS the Terreſtrial Globe has ever been very juſtly held in the higheſt Eſteem, for its Uſe in conveying the Ideas relative to the Principles of Geographical Science with the greateſt Perſpicuity and Facility, and for the Solution of all ſuch Problems in a direct and natural Manner, it may be a Wonder to many People, why it ſhould be thought of no more Conſequence in *Hydrography*, and ſo little in Uſe at Sea, when the moſt natural Repreſentation and eaſy Solution of all the Caſes of Sailing, or Problems of Navigation, are ſo readily exhibited and performed by it.— We may add to the above Conſideration, that ſince more than two Thirds of the whole Surface of the Globe is covered with Water, and the Neceſſity that Mankind are under of traverſing all Parts of this vaſt extended aqueous Surface, without any other Guide but the Compaſs and Stars, I ſay, conſidering all

DIALING by the GLOBE.

Plate IV.



Direct East Dial

Fig. 2.

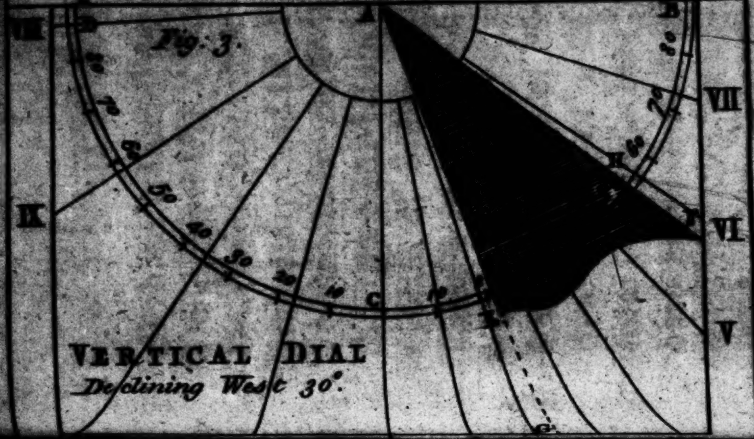


Fig. 3.

VERTICAL DIAL
Declining West 30°.

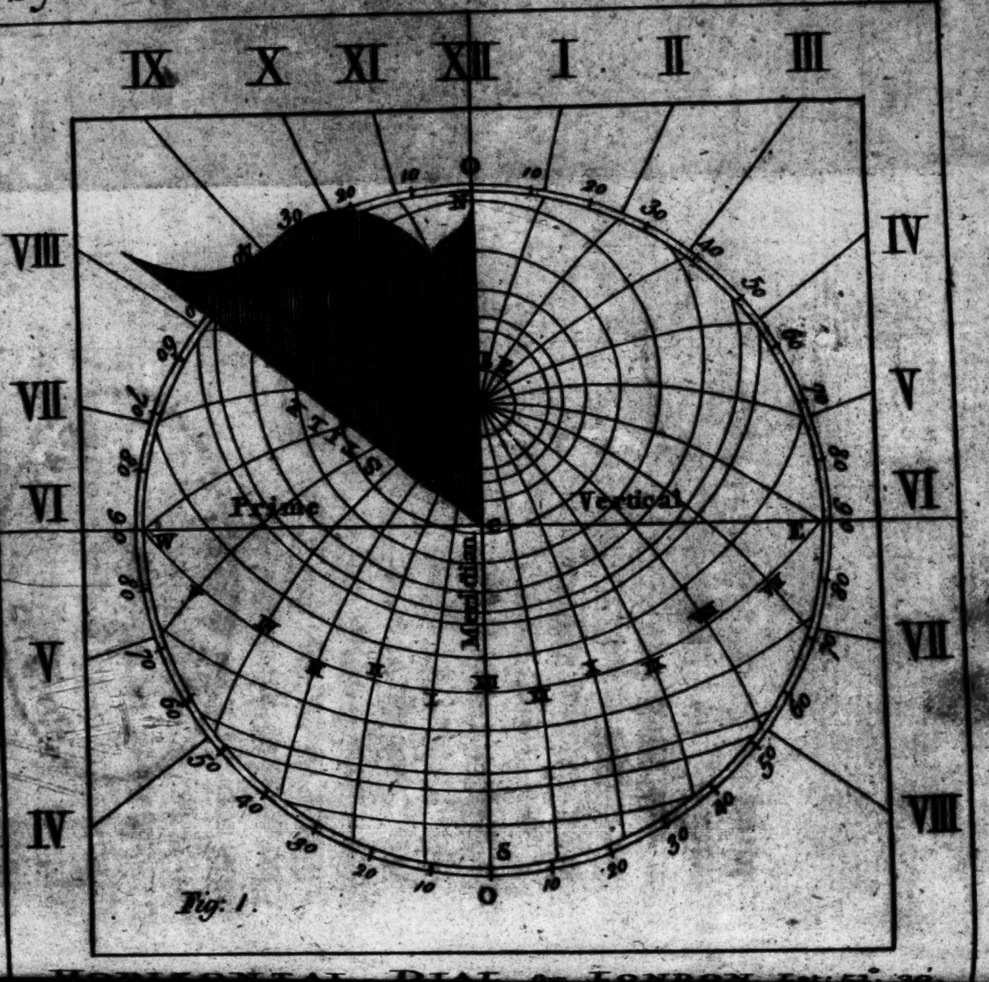


Fig. 1.

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all this, it ſhould ſeem as if the principal Deſign and Uſe of the artificial *Terraqueous Globe* were to facilitate the Principles of Hydrography, and the Practice of Navigation.

It muſt be confeſſed by every one, that tho' there be Methods invented of repreſenting a Caſe of Sailing *in Plano*, and ſolving the ſame with great Accuracy, yet ſuch an Invention is altogether artificial; whereas, the Idea we have of ſuch a Caſe of Sailing on the Surface of a Globe, is altogether natural; and whereas one requires very great Skill in Mathematical Science to comprehend the Principles on which it depends, the Method of Sailing by the Globe is ſo ſimple and plain, that the *Rationale* of every Caſe of Sailing is evident by Inſpection only.

It muſt be allowed, that ſmall Globes are not ſo well fitted to anſwer this End; but a Globe of 17 Inches Diameter has its Degrees ſo large as to give any Diſtance ſailed to 10′ or Miles, and, by the Application of a *Nonius*, even to a Minute or two, which is as much Accuracy as is ever required, and is much more than is often acquired by the common Methods of Sailing.

But when we conſider the Size of a 28 Inch Globe, and that each Degree is $\frac{1}{4}$ of an Inch in Length, all Heſitation or Difficulty about ſolving Problems with Accuracy muſt vaniſh; for Diſtances there might be meaſured to 5′, or Miles, without any Trouble of a *Nonius*, and all the other *Quæſita* of Sailing obtainable without the leaſt Degree of Trouble: And as the Terreſtrial Globe only would be neceſſary in this Caſe, and there is Room enough in the Cabins of all large Ships to diſpoſe of ſuch a Globe with Conveniency, it is a Wonder that any *Maſters*, *Captains*, or *Commanders*, of Ships, ſhould ever go to Sea without them.

But to return to Mr. *Senex*'s Globe of 17 Inches Diameter, which ſeems to have been deſigned in a peculiar Manner for anſwering the Purpoſes of Navigation, by having a great Number of *Rhumb Lines* drawn in all the convenient Parts of the Surface of the Globe repreſenting the Oceans and Seas, ſo that if a Ship is departing from any Port, it is at once evident upon what Rhumb or Courſe ſhe muſt be ſteered to reach the Port or Coaſt ſhe is bound for.——And when we conſider, with how little Accuracy and Certainty the Way of a Ship can be meaſured at Sea, or the Angle of her Courſe can be eſtimated, and the Departure, Difference of Latitude, Longitude, *&c.* found by the common Methods of Obſervation, we ſhall find no room to object againſt the Size of the Globe, which is more than ſufficient to repreſent them in a far ſuperior Degree of Truth: ſuch a Globe therefore ought to be eſteemed the moſt neceſſary Piece of Furniture in the Cabin of a Ship; and as this may be juſtly recommended for common Uſe, I ſhall now proceed to ſhew in what Method the common Caſes of Sailing are repreſented upon it, and how they are reſolvable by it.

In a Caſe of Sailing on the Globe, there are but four things properly to be conſidered, which are all found in one Spheroid or *Loxodromic* Triangle, *viz.* (1.) The DIFFERENCE of LATITUDE, (2.) The DIFFERENCE of LONGITUDE, (3.) The ANGLE of the COURSE, and (4.) The DISTANCE *Sailed.* —— Any two of theſe being given, or known, the other two when required, may be found; and from hence there will ariſe *five different* CASES of SAILING, according to the Method we take, which is two fold, *viz.*

ORTHODROMICS, or *Great Circle Sailing:* for it is to be conſidered, that the Way or Courſe of a Ship being upon a Globular Surface, the neareſt Diſtance between any two Places is the *Arch of a great Circle*; and therefore the ſhorteſt and moſt direct Way for a Ship to proceed is in ſuch an Arch; but the Arch of a great Circle will not interſect the Meridian it paſſes obliquely over in *equal Angles*, and therefore it would be required, very often, to change the Direction of a Ship's Courſe, in ſteering of her moſt directly, or the neareſt Courſe from one Port to another: Hence a ſecond Method of Sailing,

ing, or ſteering of a Ship's Courſe has been invented, *viz.*

Loxodromics, ſo called from its Sailing on an oblique Courſe, which is a Curve of ſuch a Nature or Kind as to make equal Angles every where with the Meridian; ſuch a Curve is called a *Rhumb*, eight of which are generally drawn in every Quadrant, or Quarter of a Circle, which are thoſe Lines you obſerve ſo frequently croſſing each other on the aqueous Surface of the 17 Inch Globe. This artificial Method of ſailing is by Means of the Magnetical Needle, which, as it makes a conſtant Angle with the Meridian where you are, points out to the Mariner, at the ſame Time, the Angle which his Ship's Courſe is to make with the Meridian daily.

Now, either of theſe Methods of Sailing are performable by the Globe, and would be almoſt equally eaſy, if, to qualify the Globe for anſwering ſuch Purpoſes, there were added to it, a *Movable Meridian* on the Surface and *Globular Protractor.*

For tho' one might very well ſhift without the Movable Meridian, as the Meridians on the Surface of this Globe are drawn through every 10 Degrees, yet the Solution of a Problem would be more accurate with it, and the Expence not extraordinary:——The Globular Protractor we might make a ſhift without likewiſe; but it would, in many Caſes, be found very uſeful, eſpecially in *Loxodromic*

Sailing, by which, to delineate the *Rhumb* more accurately.

We proceed now to the Problems by which the Caſes of ſailing are ſolved on the Globe, which we ſhall firſt do in a general Manner, and then afterward more particularly with Regard to the Curve on which the Courſe of the Ship is to be directed, in *great Circle* SAILING.

Prob. XXXIII. Caſe I. *Given the Difference of* LATITUDE *and Difference of* LONGITUDE *to find the* COURSE *and* DISTANCE *ſailed.*

Example: Admit a Ship ſails from a Port A in Latitude 38° to another Port B in Latitude 5°, and finds her Difference of Longitude 43°.

Let the Port A be brought to the Meridian, and elevate the Globe to the given Latitude of that Port 38°, and fixing the Quadrant of Altitude preciſely over it on the Meridian, move the ſaid Quadrant to lie over the ſecond Port B, (found by the given Difference of Latitude and Longitude) then will it cut in the Horizon 50° 45′ for the Angle of the *Ship's Courſe* to be ſteered from the Port A. Alſo, count the Degrees in the Quadrant between the two Ports, which you will find 51°: This Number multiplied by 60, (the nautical Miles in a Degree,) will give 3060 for the Diſtance run.

Prob. XXXIV. Caſe II. *Given the* Difference *of* LATITUDE *and* COURSE, *to find the* Difference *of* LONGITUDE *and* DISTANCE *failed.*

Example: Admit a Ship ſails from a Port A in 25° North Latitude to another Port B in 30° South Latitude, upon a Courſe of 43°.

Bring the Port A to the Meridian, and rectify the Globe to the Latitude thereof 25°, where fix the Quadrant of Altitude, and place it ſo as to make an Angle with the Meridian of 43° in the Horizon, and obſerve where the Edge of the Quadrant interſects the Parallell of 30° South Latitude, for that is the Place of the Port B. Then count the Number of Degrees on the Edge of the Quadrant interſected between the two Ports, and there will be found 73°, which multiplied by 60, gives 4380 Miles for the Diſtance ſailed.—— As the two Ports are now known, let each be brought to the Meridian, and obſerve their Difference of Longitude in the Equator reſpectively, which will be found 50°.

N. B. Had this Problem been ſolved by *Loxodromics,* or ſailing on a Rhumb, the Difference of Longitude would then have been 52° 30′ between the two Ports.

Prob. XXXV. Caſe III. *Given the* DIFFERENCE *of* LATITUDE *and* DISTANCE *run, to find*

find the DIFFERENCE *of* LONGITUDE *and* ANGLE *of the* COURSE.

Example: Admit a Ship ſails from a Port A in Latitude 50°, to another Port B in Latitude 17° 30′, and her Diſtance run be 2220 Miles: Rectify the Globe to the Latitude of the Place A, then the Diſtance run, reduced to Degrees, will make 37°, which are to be reckoned from the End of the Quadrant lying over the Port A under the Meridian; then is the Quadrant to be moved till the 37° coincides with the Parallel of 17° 30′ North Latitude, then will the Angle of the Courſe appear in the Arch of the Horizon intercepted between the Quadrant and the Meridian, which will be 32° 40′; and by making a Mark on the Globe for the Port B, and bringing the ſame to the Meridian, you will obſerve what Number of Degrees paſs under the Meridian, which will be 20°, the Difference of Longitude required.

Prob. XXXVI. Caſe IV. *Given the* DIFFERENCE *of* LONGITUDE *and* COURSE, *to find the* Difference *of* LATITUDE *and* DISTANCE *ſailed.*

Example: Suppoſe a Ship ſails from A, in the Latitude 51°, on a Courſe making an Angle with the Meridian of 40°, till the Difference of Longitude be found juſt 20°: Then rectifying the Globe to the Latitude of the Port A, place the Quadrant of Altitude ſo as to make an Angle of 40° with the Meridian; then obſerve in what Point it interſects the Meridian paſſing through the given Longitude of the Port B, and there make a Mark to repreſent the ſaid Port; then the Number of Degrees intercepted between that and the Port A will be 28°, which will give 1680 Miles for the Diſtance run:——And the ſaid Mark for the Port B, being brought to the Meridian, will have its Latitude there ſhewn to be 27° 40′.

Prob. XXXVII. Caſe V. *Given the Courſe and Diſtance ſailed to find the Difference of Longitude and Difference of Latitude.*

Example: Suppoſe a Ship ſails 1800 Miles from a Port A 51° 15′ South Weſt, on an Angle of 45°, to another Port B.

Having rectified the Globe to the Port A, fix the Quadrant of Altitude over it in the Zenith, and place it to the South Weſt Point in the Horizon; then upon the Edge of the Quadrant under 30° (equal to 1800 miles from the Port A) is the Port B; which bring to the Meridian, and you will there ſee the *Latitude*; and at the ſame Time, its *Longitude* in the Equator in the Point cut by the Meridian.

In all theſe Caſes, the Ship is ſuppoſed to be kept upon the *Arch of a great Circle*, which is not difficult to be done, very nearly, by Means of the Globe, by frequently *obſerving the Latitude, meaſuring the Diſtance* ſailed, and (when you can) *finding the Difference of Longitude*; for one of theſe being given, the place and Courſe of the Ship is known at the ſame Time; and therefore the preceding Courſe may be altered, and rectified without any Trouble, through the whole Voyage, as often as ſuch Obſervations can be obtained, or it is found neceſſary. Now if any of theſe *Data* are but of the Quantity of four or five Degrees, it will ſuffice for correcting the Ship's Courſe by the Globe, and carrying her directly to the intended Port, according to the following Problem.

Prob. XXXVIII. *To ſteer a* SHIP *upon the* ARCH *of a* GREAT CIRCLE *by the given Difference of* Latitude, *or Difference of* Longitude, *or* DISTANCE *ſailed in a given* TIME.

Admit a Ship ſails from a Port A, to a very diſtant Port Z, whoſe *Latitude and Longitude* are given, as well as its *Geographical Bearing* from A; then,

Firſt, having rectified the Globe to the Port A, lay the Quadrant of Altitude over the Port *Z*, and draw thereby the Arch of a *Great Circle* through A and Z; this will deſign the intended Path or Tract of the Ship.

Secondly, having kept the Ship upon the firſt given Courſe for ſome Time, ſuppoſe by an Obſervation you find the Latitude of the *preſent Place* of the Ship, this added to, or ſubducted from the Latitude of the Port A, will give the preſent Latitude in the Meridian; to which bring the Path of the Ship, and the Part therein, which lies under the new Latitude, is the true Place B of the Ship in the great Arch. To the Latitude of B rectify the Globe, and lay the Quadrant over Z, and it will ſhew in the Horizon, the *new Courſe* to be ſteered.

Thirdly, ſuppoſe the Ship be ſteered upon this Courſe till her Diſtance run be found 300 miles, or 5°; then, the Globe being rectified to the place B in the Zenith, laying the Quadrant from thence over the Great Arch, make a Mark at the 5th Degree from B, and that will be the preſent Place of the Ship, which call C; which being brought to the Meridian, its Latitude and Longitude will be known. Then rectify the Globe to the Place C, and laying the Quadrant from thence to Z, the new Courſe to be ſteered will appear in the Horizon.

Fourthly, having ſteered ſome Time upon this new Courſe, ſuppoſe, by ſome Means or other you come to know the Difference of Longitude of the preſent Place of the Ship, and of any of the preceding Places, C, B, A; as B, for Inſtance; then bring B to the Meridian,

dian, and turn the Globe about, till ſo many Degrees of the Equator paſs under the Meridian as are equal to the diſcovered Difference of Longitude, then the Point of the *Great Arch* cut by the Meridian is the preſent Place D of the Ship, to which the new Courſe is to be found as before.

And thus, by repeating theſe Obſervations at proper Intervals, you will find future Places E, F, G, *&c.* in the great Arch; and by rectifying the Courſe at each, your Ship will be conducted on the great Circle, or the neareſt Way from the Port A to Z, by the *Uſe of the Globe* only.

And were the Globe properly fitted up with all the uſeful Apparatus; it would convey the cleareſt Notions of *Spherical Trigonometry* in general, and its Application to ASTRONOMY, GEOGRAPHY, DIALLING, NAVIGATION, *&c.* of any Inſtrument whatſoever. But, for more general Inſtructions on this Head, I muſt refer the Reader to the INSTITUTES of NAVIGATION, publiſhed in the GENERAL MAGAZINE *of* ARTS *and* SCIENCES.

Loxodromic SAILING is too difficult by the *Globe*, and better performed by *Mercator*'s CHART, or a new *Marine* PPAIN TABLE, and *Nautical* SLIDING RULE, of which I propoſe very ſoon to draw up a Deſcription, as alſo of a farther Improvement and new Conſtruction of both *Davies*'s and *Hadley*'s QUADRANT in a ſmall Treatiſe of INSTRUMENTAL NAVIGATION.

CHAP.

LIBRARY

CHAP. IV.

A NEW CONSTRUCTION *of the* Terreſtrial GLOBE by CLOCK-WORK, *exhibiting all the* Phænomena *of the* annual and diurnal MOTIONS *thereof, in the moſt natural and general* MANNER.

HAVING diſpatched the geographical Problems of the Terreſtrial Globe, according to the uſual Form thereof, I muſt here beg Leave to obſerve, that this Globe is capable of a much more genuine and natural Conſtruction, and its Uſe in a Solution of geographical Problems will be found much more rational and eaſy, as the Poſition of this Globe and its Motions will be always ſimilar and exactly correſpond with that of the large Globe of Earth itſelf.———'Tis true, this Diſpoſition of the Globe is more expenſive than the common one, as requiring a Sort of Clock-work to give it Motion: But then the very Globe itſelf, when furniſhed with its proper Circles and Appendages, gives, by Inſpection, without any Trouble to the Student, a moſt natural Solution to all this Kind of Problems; ſo that after ſuch a Globe is rectified, it becomes an AUTOMATON, being always in Motion, and exhibiting the ſame Phænomena as he would obſerve on the very Earth itſelf, if ſituated at a Diſtance from it.

For the Sake, therefore, of ſuch as may chuſe to indulge a rational Curioſity, and take the moſt direct and demonſtrative way to Knowledge, I ſhall give a brief Deſcription of this Machine, and its Uſes, as in this way the *Rationale* of Geography, rather than a practical Solution of Problems, is the principal Object in View.

Firſt, By the Mechaniſm of this Globe, the Axis has a conical Motion on its Center, by which it makes one Revolution in the Space of one whole Year, by which Means the Poles of the World deſcribe round the Poles of the Ecliptic a Circle of 47° in Diameter, the Axis of the Ecliptic being always perpendicular to the Horizon with reſpect to this annual Motion.

Secondly, Upon the lower Part of the Foot is placed a ſilvered horizontal Circle, containing the Ecliptic with its Signs and Degrees, and a Calendar with its Months and Days correſponding thereto.

Thirdly, In a Part of the Stem, or Foot which ſupports the Globe, is an Index moving over the aforeſaid Circle, indicating the Poſition of the Earth's Axis, agreeable to the Time or Seaſon of the Year, which is ſhewn in the Calendar.

Fourthly, By another Part of the Machinery, another Motion is communicated to the Globe, by which it is carried once round upon its Axis in the Space of a natural Day, or 24 Hours. In this Motion the Poles of the Ecliptic revolve every Day about the Poles of the World, at the Diſtance of 23° 30′.

Fifthly, To eſtimate any Part of this diurnal Motion of the Earth, there is a horary Circle annexed, with its proper Index for ſhewing the Hour, and Parts thereof.

Sixthly, At a convenient ſmall Diſtance is fixed a Circle called *the Circle of Illumination*, which divides the Globe into two Hemiſpheres, *viz.* one always illumined by the Sum Beams, and the other wholly dark.

Seventhly, At a proper Diſtance from the Surface of the Sun, correſponding to the middle Point of the enlightened Hemiſphere, is fixed a ſmall braſs Ball to repreſent the SUN; but at Night, a ſmall Lamp, or wax Candle will be neceſſary. Theſe are the principal Parts without the Globe; but on the Surface of the Globe itſelf, the following Circles are contained.

Eighthly, Two great Circles interſecting each other, at Right Angles, in the Poles of the World, and moveable thereon to any Part of the Earth's Surface.

Ninthly, On the middle Point of one of theſe is placed another great Circle, moveable, to make any given Angle therewith, and conſequently is properly adapted to repreſent the *Horizon* of any given Place, the *Meridian* of which is repreſented by the other great Circle of the Two before mentioned.

Tenthly, At 18° diſtant from the horizontal Circle is fixed another, called the *Crepuſcular* Circle, ſhewing the Beginning and End of Twilight at any particular Place.

There are other Parts of Machinery which are appropriated to the Nature of Solar and Lunar Eclipſes, Tranſits of the Planets, *&c.* but as theſe Things are rather Appurtenances than what neceſſarily belong to the Globe, and the Subjects of Aſtronomy rather than Geography, I ſhall here paſs them by, and ſhall refer the Reader to the *Young Gentleman and Lady's Philoſophy*, in the *Magazine of Arts and Sciences*, for the Year 1760, where he will find a full Account of them and their Uſes.

In order to rectify this Globe for Uſe, the firſt Thing to be done is, to put the Axis of the Globe into a Poſition ſimilar to that of the real Globe, by moving the Machine till the Index comes to the given Day of the Month, when you uſe it: Then the horizontal Circle is to be adapted to the Place where you are, ſuppoſe the City of *London*, for Inſtance: — *Laſtly*, Move the Globe on its Axis till the preſent Hour and Minute of the horary Circle comes to the Index, then will the Globe, or any Part of the Surface, have the ſame Situation with reſpect to the Solar Ball, or Lamp, as the real Globe of the Earth has itſelf at that Time to the Sun: —— And if now you hang on the Weight, the Globe will be put into Motion, and all the Phænomena of Days and Nights, Seaſon of the Year, &c. will appear in one natural View.

Thus, for Example: To rectify the Globe for the firſt Day of *April*, you bring that Day in the Calendar to the annual Index, and becauſe it then appears that the Sun is in the 12° of *Aries*, therefore you will ſee that Point of the Ecliptic, upon the Globe, ſtand under the Solar Ball, or artificial Sun; then move the Globe about till the Meridian of the given Place, as *London*, paſſes through the Sun, where letting the Globe reſt, move the Hour Circle till the Hour of XII comes to the horary Index: Then let the Horizon of *London* have its proper Poſition given it, and the Machine being put into Motion, you will obſerve all the Phænomena of that Day and Night to follow each other, in a natural Manner, in the Space of one Revolution of the Globe on its Axis: —— Particularly you will ſee the North Pole a little way within the enlightened Hemiſphere, and the Southern Pole as far in the dark one.——By this Means you will obſerve, that all the Parts in northern Latitudes are turned more directly to the Sun, whoſe Beams are therefore ſtronger:——Alſo you obſerve, that the Tract which each Place in North Lat. deſcribes in the enlightened Hemiſphere is maniſeſtly longer than that which is deſcribed in the dark one. Therefore the Seaſon of the Year, in the Parallel of the City of *London*, muſt be warmer and more lightſome than in any Place of an equal Latitude South, where the Days are evidently as much ſhorter than the Nights, as they are longer with us; for the Alteration of Days and Nights, according to the Latitudes North or South, does here equally, and at once appear.——If you look on any particular Place, as the Iſland of *Great Britain*, you ſee it enter the enlightened Hemiſphere at Sun-riſing, becauſe then the Sun is in the Horizon upon the Globe; for when any Place is under the Circle of Illumination, the Sun muſt neceſſarily be in the Horizon at that Place, becauſe the Sun, being in the Zenith of the enlightened Hemiſphere, muſt be 90° from the Place.——From hence it will alſo appear, that when the City of *London* comes on the other Side of the Circle of Illumination, then likewiſe the Sun appears again in its Horizon, and conſequently you have here a moſt natural View of thoſe great Phænomena of the Riſing and Setting of the Sun in any given Place, and on any given Day of the Year. —— At the ſame Time, you ſee it is Noon when the Meridian of the Place comes juſt under the Sun, and that it is Midnight when the oppoſite Part of that Meridian comes to the Sun; becauſe then the Place is exactly in the middle Part of its Path in the dark Hemiſphere.

But that all theſe Things may appear in their greateſt Quantity, you may move the annual Index to the Beginning of *Cancer*; then it will appear, that the Circle of Illumination is juſt over the Arctic Circle, or that the North Pole is within the enlightened Hemiſphere juſt 23° 30′, and, conſequently, that, by putting the Globe into Motion, it will appear, that all the Space contained within the Arctic Circle is intirely illumined that Day, and all within the Antarctic Circle wholly contained in the dark Hemiſphere. — The Places in North Latitude have now their neareſt Poſition to the Sun's perpendicular Beams, and, conſequently, his Rays will fall moſt directly upon them, and of Courſe a greater Number of Rays will fall upon any given Place than at any other Time: The Sun Beams alſo now paſs through a leſs Quantity of the Earth's Atmoſphere in Northern Latitude. To all which if we add, that the Length of Days now greatly exceed the

Length of the Nights, it will ſhew this to be the hotteſt and moſt lightſome Seaſon of the Year to all the Northern Latitude: and juſt the contrary appears in all the Southern Latitude. In the ſame View, you have their Depth of Winter, ariſing from juſt contrary Cauſes, *viz.* the Shortneſs of Days, and the Obliquity of the Sun Beams falling on thoſe Parts of the Earth, now at their greateſt Remove from the Sun's perpendicular Beams.

With reſpect to the Twilight for any particular Place, you will obſerve, that while that Place is deſcribing its natural Arch, the Crepuſcular Circle will naturally ſucceed the Horizon, and at Length come upon the Sun; then will the Twilight end, and the Time ſhewn by the Horary Index, ſubtracted from the Time of Sun-ſetting, will leave the Length of the Twilight for the Evening of that Day: —— Then, as the Globe revolves, the upper Part of the Circle of Twilight will come upon the Sun, and the Index will ſhew the Time of Day-break, or Beginning of Twilight for that Morning.—— In this View of the Globe it will alſo appear, what Places in North Latitude can have no dark Night at *Midſummer*, *viz.* all thoſe which are contained between 48° 30′ of North Latitude and the Arctic Circle; for in the Midnight Situation of the Globe the Sun will be ſeen between the Horizon and the Crepuſcular Circle.—— For Inſtance: *London*, in the Middle of its Nocturnal Path, will not be more than 15° from the Circle of Illumination: therefore, the Sun at Midnight will be no more than 15° below its Horizon

If we now remove the annual Index to point to the Beginning of *Aries*, or *Libra*, we ſhall then obſerve all the Phænomena of the Equinoctial Seaſons: —— The Sun appears now in the Equator: —— The Poles of the World are both under the Circle of Illumination: —— Conſequently, as the Globe revolves, every Place, from Pole to Pole, will deſcribe an equal Arch in the enlightened and dark Hemiſpheres: —— For they will enter into, and go out of each, exactly at VI o'Clock, as ſhewn by the Hour Index. —— All Parts have now their mean Inclination to the Sun Beams; their Effects will therefore be of a mean Degree, and conſequently produce a temperate Seaſon, between the Extreams of Summer's Heat and Winter's Cold.

Laſtly, By turning the annual Index to point to the Beginning of *Capricorn*, we obſerve the North Pole turn from the Sun, and, at length, wholly included in the dark Hemiſphere: — The South Pole is now ſeen in the enlightened Hemiſphere juſt as far. —— All the Parts in Northern Latitudes now have their *Winter Seaſon*, as thoſe in Southern Latitudes have their *Summer*. ——The Lengths of Days and Nights are now juſt inverſely what they were when the Sun entered *Cancer*. —— The City of *London*, in the Midſt of its diurnal Path, is now but 15° within the enlightened Diſk, or from the Circle of Illumination at Noon; and therefore the Sun, of Courſe, can aſcend no higher above his Horizon on the Midwinter Day, or its Meridian Altitude will then be but 15°. — All the other Appearances for this Seaſon are obvious in the Space of one Revolution, and need not be repeated.

To conclude: If, by CLOCK-WORK, both the annual and diurnal Motions were given to a Globe of this Conſtruction, (as they eaſily might be) the Phænomena of every Day and Night, and all the Seaſons of the Year, will be conſtantly ſhewn as they returned in Nature: And thus the *artificial Globe* might keep Pace with the *Natural*, in all its Motions and Appearances, and ſo prove an Automaton demonſtrative of the *Rationale* of all the Principles of Geography; and therefore the moſt compleat Inſtructor in that moſt uſeful and delightful Science.

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CHAP. V.

The Deſcription and Uſe of a New MANUAL ORRERY.

THE Price of *Orreries* being very great, is one Reaſon why this moſt uſeful Machine is not ſo common, as one might wiſh it were, on Account of its great Service in conveying an eaſy and adequate Idea of the true Conſtitution of the SYSTEM of the WORLD, and, of Courſe, the firſt Principles of ASTRONOMY and GEOGRAPHY; ſo eſſential a Part of the Education which our *Engliſh* Youth ſhould have. In order to remove this Difficulty, I have contrived a *Manual* ORRERY, that ſhall come at a ſmall Price, and will readily ſhew what is, and what is not the true Syſtem of the World, with its various *Phænomena*, or Appearances of DAY and NIGHT, Viciſſitude of the SEASONS, Nature of ECLIPSES, *&c.* as will be eaſy to apprehend from an Account of its Structure and various Uſes, as follows.

I. This Machine is made to repreſent the *Ptolemaic Syſtem*, or ſuch as is vulgarly received,

ceived, which places the Earth in the Center, and the Planets and Sun revolving about it. And at the ſame Time affords a moſt manifeſt Confutation of it. For you plainly ſee, in this Conſtruction, (1.) That the Planets *Mercury* and *Venus*, being both within the Orbit of the Sun, cannot be ſeen at any Time to go behind it; whereas we obſerve them as often to go behind, as before the Sun, in the Heavens. (2.) It ſhews, that as the Planets move in Circular Orbits about the Central Earth, they ought at all Times to be of the *ſame apparent Magnitude*; whereas, on the Contrary, we obſerve the apparent Magnitude in the Heavens to be very variable, and ſo far different, that (for Inſtance) *Mars* will ſometimes appear a big as *Jupiter* nearly, and at other Times you will ſcarce know him from a fixed Star. (3.) It ſhews, that any of the Planets might be ſeen at all Diſtances (from the Sun) in the Heavens, or, in other Words, that when the Sun is ſetting, *Mercury* or *Venus* may be ſeen not only in the *South*, but even in the *Eaſt*; which Things were never yet obſerved. (4.) You ſee, by the Orrery, that the Motions of the Planets ſhould always be *regular* and *uniformly the ſame*; whereas, on the Contrary, we obſerve them always move with a variable Velocity; ſometimes faſter, then ſlower, and ſometimes not at all. (5.) By the Machine you ſee the Planets move all the *ſame Way*, *viz.* from

Weſt to *Eaſt* continually. But in the Heavens we ſee them move ſometimes *direct* from *Weſt* to *Eaſt*; ſometimes *Retrograde*, from *Eaſt* to *Weſt*, and at other Times to be *Stationary*. All which plainly prove this Syſtem to be a *falſe and abſurd Hypotheſis*.

II. The Truth of the *Copernican*, or SOLAR SYSTEM of the WORLD, which places the Sun in the Center, and the Earth among the Planets, is hereby moſt clearly repreſented. For taking the Globe of the Earth from the Center, and placing thereon a large gilt Ball for the Sun, and reſtoring the Earth to its proper Situation among the Planets, then every Thing will be right, and agree exactly with celeſtial Obſervations. For turning the Winch, (1.) you will ſee the Planets *Mercury* and *Venus* go both before and behind the Sun. (2.) You will obſerve *Mercury* never to be more than 21°, and *Venus* 47°, from the Sun. (3.) That the Planets, and eſpecially *Mars*, will be ſometimes much nearer to the Earth than at others, and therefore muſt appear much larger at one Time than at another. (4.) You will ſee that the Planets cannot appear at the Earth to move with an *uniform Velocity*; for when neareſt, they appear to move faſter, and ſlower when moſt remote. (5.) You will obſerve the Planets will appear at the Earth to move ſometimes directly from *Weſt* to *Eaſt*; and then to become *retrograde* from *Eaſt* to *Weſt*; and beſween both, to be Stationary, or without any apparent Motion at all. Which Things all correſpond exactly with Obſervations, and fully prove the TRUTH of this excellent Syſtem.

III. All the *Primary* PLANETS are here diſpoſed about the Sun, and all the Secondaries, or *Satellites*, about their Primaries, in ſuch Order as we ſee them in the Heavens. Again, you may here repreſent the Syſtem in two Parts, *viz.* of the *inferior Planets*, and of the *ſuperior*; and then the true comparative Diſtances of each Planet from the Sun, and among themſelves, may be ſeen; and many very curious Things obſerved, which depend thereon; as the true *Heliocentric*, and *Geocentric Places*, the *Parallatic Angle*, the *Elongation*, and the true Proportion of *Diſtance* from the Sun, *&c.* which are the very *Fundamentals* of ASTRONOMY; and are here known, as it were, by Inſpection only.

IV. By this Machine you at once ſee all the Planets in Motion about the Sun with the *ſame reſpective Velocities*, and *Periods* of *Revolution* which they have in the Heavens. The Work being calculated to a Minute of Time.

			Miles.		D.	H.	M.
Thus	*Mercury*	at the Diſtance of about	3200000	revolves in	87	23	16
	Venus		5900000		224	16	49
	Earth		8200000		365	6	9
	Mars		12300000		686	23	27
	Jupiter		42400000		4332	12	20
	Saturn		77700000		10759	6	36

And here alſo the Great and General Law of the Planetary Motions may be obſerved, *viz. That every where the Squares of the Periodical Times are proportional to the Cubes of the Diſtances reſpectively.*

V. You will here ſee a Demonſtratiom of the Earth's Motion about the Sun, as well as of the Reſt of the Planets; for if the Earth were to be at Reſt in the Heavens, then the Time between any two *Conjunctions* of the ſame Kind, or *Oppoſitions*, would be the ſame with the *Periodical Time* of the Planets, *viz.* 88 Days in *Mercury*, 225 in *Venus*, *&c.* Whereas you here obſerve, this Time inſtead of being 225 Days, is no leſs than 583 Days in *Venus*; occaſioned by the Earth's moving in the mean Time about the Sun the ſame Way with that Planet. And this Space of 583 Days always paſſes between two like Cojunctions of *Venus* in the Heavens. Hence the moſt important Point of Aſtronomy is ſatisfactorily demonſtrated.

VI. The *Diurnal Rotation* of the Earth about its Axis, and *a Demonſtration of the Cauſe of the different Seaſons of the Year, and different Lengths of Day and Night*, are here anſwered by placing the Earth in the Center on an Axis inclined to that of the Ecliptic in an Angle of 23 ½ Degrees, and making the Sun move about it through all the Signs of the Ecliptic; then will all the Variety of Seaſons appear from the ſame Cauſes as in the common Orreries, *viz.* (1.) from the different Inclination of the Sun's Rays; (2.) the different Quantity thereof which falls on a given Space; (3.) the different Quantity of the Atmoſphere they paſs thro'; and (4.) the different Continuance above the Horizon, at the ſame Place in different Times of the Year; which Particulars conſtitute the Difference betwixt SUMMER and WINTER.

VII. As the Globe of the Earth is movable about its inclined Axis, ſo by having the Horizon of *London* drawn upon the Surface of it, and one half (*viz.* that oppoſite the Sun) always covered with an Hemiſphere of black Crape; you will here (more naturally than in any other Orrery,) ſee the Cauſe of the *different Lengths* of DAY and NIGHT, by obſerving the unequal Portions of the Circle which the Iſland of *Great Britain*, or the City of LONDON (or any other Place) deſcribes in the light and dark Hemiſpheres, at different Times of the Year, by turning the Earth on its Axis with the Hand.

VIII. As to the ECLIPSES of the *Sun* and *Moon*, the true Cauſes of them are here very clearly ſeen; for when the Moon is placed in a Right Line between the Centers of the Sun and Earth, her Shadow (by Candle-Light) will fall on the Earth, and all who live on that Part over which the Shadow paſſes will ſee the Sun eclipſed more or leſs. On the other Side, the Moon paſſes (in the aforelaid Caſe) through the Shadow of the Earth, and is by that Means eclipſed. And the Mechaniſm of this Orrery is ſuch, that any one who has a Mind to do it, may eaſily repreſent the due POSITION and NODES of the *Moon's Orbit*; and thence ſhew when there will or will not be an Eclipſe of either Luminary; and what the Quantity of each will be; but this Affair I leave to the Purchaſer, unleſs proper Allowance be made for it in the Price.

IX. While the Moon is moving about the Earth in the Center; if a Candle, or rather a glaſs Lamp, be placed at a proper Diſtance to enlighten the Earth and Moon, you will ſee all the Phaſes of the Moon, as *new*, *dichotomized*, *gibbous*, *full*, *waining*, *&c.* juſt as they appear in the Heavens. You will moreover obſerve all the ſame Phaſes of the Earth as they appear at the Moon.

X. The SATELLITES of JUPITER and SATURN are movable only with the Hand; yet may all their Phænomena be eaſily repreſented excepting the true relative Motions and Diſtances, thus: If that gilt Globe which before repreſented the Sun, be made now to denote *Jupiter*, and four of the Primary Planets only be retained, then will the *Jovian* Syſtem be repreſented; and by Candle-light you will ſee (the Machine being in Motion) the *Immerſions* and *Emerſions* of the Satellites into and out of *Jupiter*'s Shadow. You will ſee plainly the Manner in which they tranſit his Body, and their Occultations behind it. You will obſerve the various Ways in which one or more of thoſe Moons may at Times diſappear. And if the Machine be ſet by a white Wall, *&c.* then, by the Projection of their Shadows, will be ſeen the Reaſons why thoſe Moons always appear on each Side *Jupiter* in a Right Line; why thoſe which are moſt remote may appear neareſt, and *è contrario.* And the ſame may be done for *Saturn*'s *Five* Moons, and his Ring.

XI. The Machine is not only ornamented, but rendered more generally uſeful, by the Plate I ſome Years ago publiſhed under the Title of SYNOPSIS SCIENTIÆ COELESTIS; which is here made the Baſis of the Orrery, having the SOLAR SYSTEM in the Center; the Earth in 8 different Poſitions about the Sun; the Circular CALENDAR of MONTHS and DAYS for the *Old* and *New Stile*; over which the Planets move, and by which their Motions may be compared and eſtimated. Then follow various Aſtronomical Circles, *viz. Right Aſcenſion*, *Declination*, *Amplitude*, *Equation of Time*, *Twilight*, *Phaſes of Saturn's Ring* during his *whole Period*, *&c.* with their ſeveral Uſes in the Sphere, all in one View; and, laſtly, a large and beautiful ECLIPTIC of the *Twelve* SIGNS here makes the *Solar* HORIZON, wherein the Place of the Sun, and

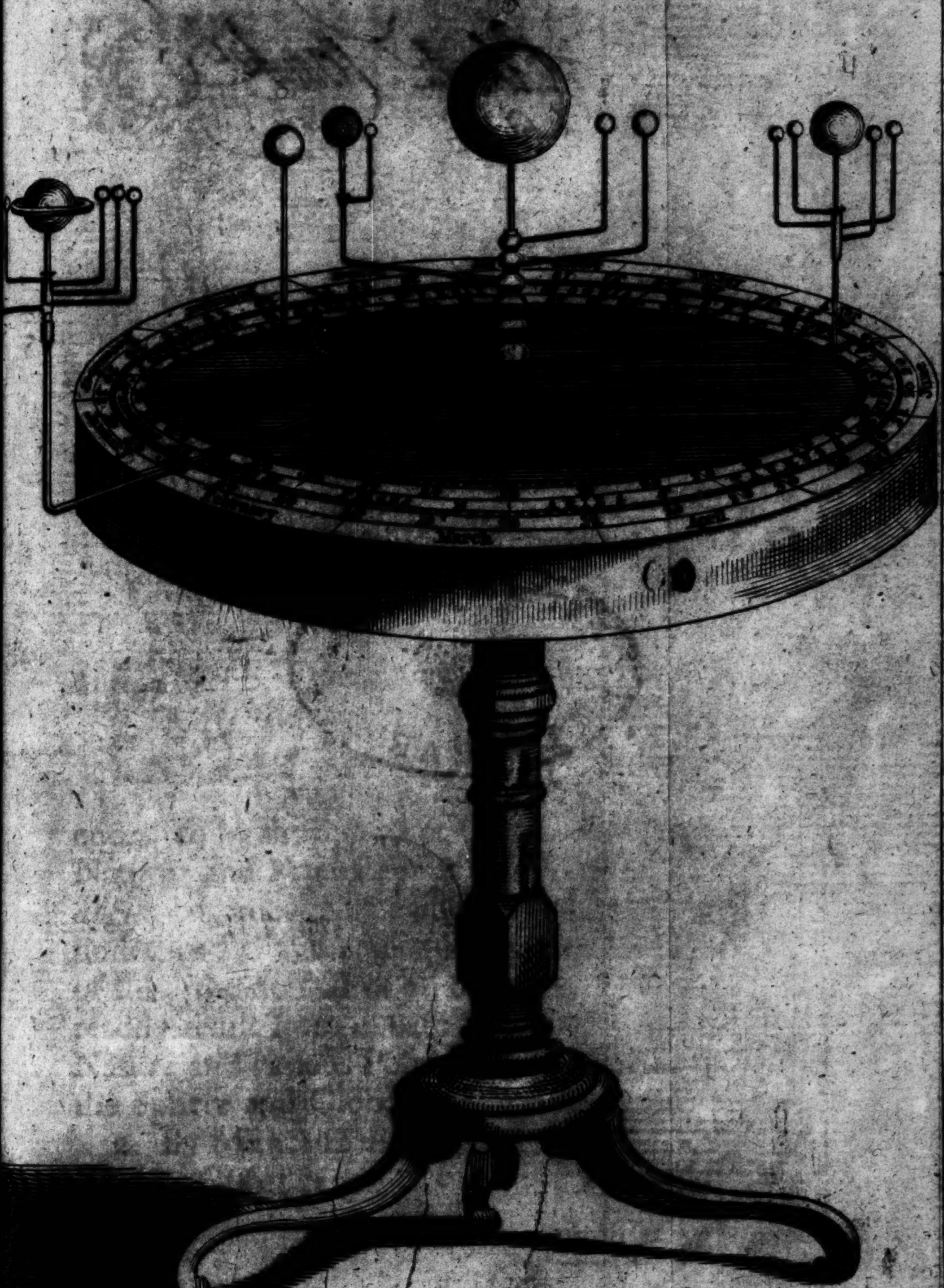
Heliocentric Places of all the Planets are at any Time to be ſhewn.

XII. Laſtly; That *Grand Phænomenon*, the *Revolution* of the *Pole of the World* about the *Pole of the Ecliptic* in a retrograde Manner, in the Space of 25920 Years, (called the *Great* PLATONIC YEAR) may here alſo be repreſented; and, of Courſe, the *Receſſion* of the *Equinoctial Points*, the *Motion* of the *Stars* apparently forward through all the Degrees of the Ecliptic; the *Anticipation* or *Preceſſion* of the Equinoctial Days, and the *Mutation of Seaſons* through all the Calendar, with many other Particulars, will by this Means be ſhewn, and the *Rationale* of thoſe otherwiſe myſterious Subjects will evidently appear.

C H

A NEW ORRERY by CLOCK-WORK.

Plate V.



A New Orrery by Clock Work

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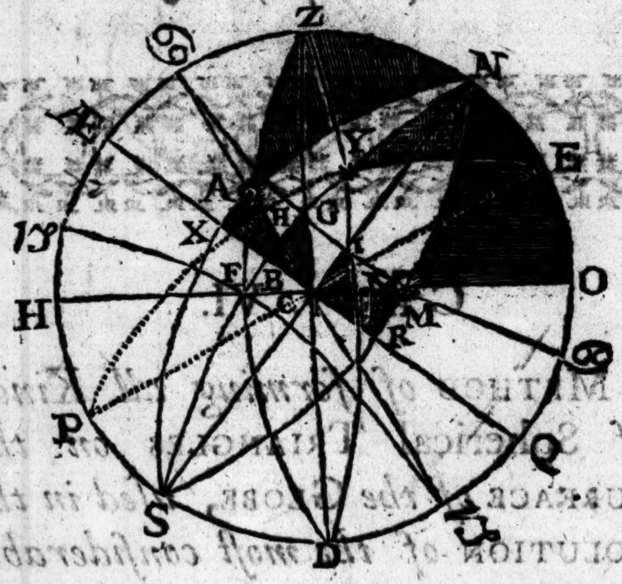
CHAP. VI.

The METHOD *of forming all Kinds of* Spherical TRIANGLES *on the* SURFACE *of the* GLOBE, *uſed in the* SOLUTION *of the moſt conſiderable* PROBLEMS *in* GEOGRAPHY, ASTRONOMY, DIALLING, NAVIGATION, *&c. with the* Rationale *of the ſame.*

1. AS *Spherical* TRIGONOMETRY is the Ground-work of all the Practice and Calculations in the abovementioned moſt uſeful Sciences, ſo by the Sphere or Globe, the Origin, Nature, and Formation of *this Kind of Triangles* becomes moſt evident, and eaſy to be underſtood; and conſequently the *Rationale* of this, the nobleſt of all Sciences, will moſt readily reſult from a bare Speculation of the Nature and various Poſitions of the Circles of the Sphere and Globes.

2. By MERIDIANS from the *Poles* of the *World,* CIRCLES of LATITUDE from the



Poles of the *Ecliptic*, and the QUADRANT of ALTITUDE, as a general *Vertical Circle*, various Interſections are produced, and thereby numerous ſpherical Triangles will be formed, as will be evident from the annexed PROJECTION of the SPHERE *in Plano* for the Latitude of LONDON; wherein

Z is the Zenith of the Obſerver.

N, S, the North and South Poles of the World.

E, P, the Poles of the Ecliptic.

A, Y, Z, the Places of the Sun, Star, City, Ships, *&c.*

Æ N Q S, the General Meridian.

N S, the Axis of the Sphere.

Æ Q, the Equinoctial Line.

H O, the Horizon of *London*.

♋ C ♑, the Ecliptic, or Sun's Path.

Z D, the *Prime Vertical*, or *Azimuth*.
E P, the Axis of the Ecliptic.
N A S, an Hour-Circle or Meridian.
Z A D, an Azimuth Circle.
E Y P, a Circle of Longitude.
♋ ♋, the Tropic of *Cancer*.
♑ ♑, the Tropic of *Capricorn*.

3. By means of theſe Circles various Spherical Triangles are formed for Calculation. Thus let A be the Place of the Sun in the Ecliptic; then in the Right-angled Triangle A X C, we have

C A, the Sun's *Diſtance*, or Longitude from the Equinox C.
A X, the Sun's *Declination* North.
C X, the Sun's *Right Aſcenſion*.
A C X, the Angle of Obliquity of the *Ecliptic*.

4. And ſuppoſing the Sun riſing in the Horizon at M on the Day of the Summer Tropic, and NMS, an Hour-Circle; then there is formed the Right-angled Triangle NOM, in which we have

N O, = Æ Z, = the *Latitude* of the Place *Z*.
M O, the *Amplitude* from the North.
N M, the Complement of the Sun's *Declination* R M.
O N M, the Angle of the *Hour* from Midnight.
O M N, the Angle of the Sun's *Poſition*.

5. On the ſame Tropical Day the Sun is at I at Six o'Clock, becauſe the Hour-Circle of Six is projected upon the Axis N C S; therefore in the Right-angled Triangle I C K, we have

I K, the Sun's *Altitude* at Six.
C K, the *Azimuth* from the Eaſt at Six.
C I, the *Declination* North.
I C K, the *Latitude* of the Place.

6. Again; when the Sun on the ſame Day comes to the *Prime Vertical* Z C D, his Place when due *Eaſt* and *Weſt* is at G; therefore in the Right-angled Triangle G B C, we have

G B, the Sun's *Declination* North.
G C, the Sun's *Altitude* when Eaſt or Weſt.
B C, the *Hour* of his being due Eaſt or Weſt.
B C G, the *Latitude* of the Place.

7. Suppoſe the Sun in the Horizon at M once more; then in the Right-angled Triangle M C R, we have

C M, the *Amplitude* from Eaſt or Weſt.
M R, the *Declination* North.
C R, the *Aſcenſional Difference*.
R C M, the *Co-Latitude* of the Place.
R M C, the Angle of *Poſition*.

8. In the oblique Triangle A Z N, we have

Z N, the *Co-Latitude* of the Place Z.
A N, the *Co-Declination*.
A Z, the Complement of the *Altitude* A F.
A N Z, the *Hour* from Noon, equal to Æ, X.

A Z N, the *Azimuth* from the North.

And the ſame may be done for any Star at A, or any other Place.

9. Again; let Y be any Star, then in the oblique Triangle Y N E, we have

Y E, the *Co-Latitude* of the Star, *viz.* Y K.

Y E, the *Co-Declination* of the Star.

N E, = Æ ♋ = the *Obliquity* of the Ecliptic.

N E Y, the Star's *Longitude* in the Ecliptic.

E N Y, the *Hour* for Midnight.

10. With reſpect to *Geographical Problems*, let Z, and A be two CITIES, then in the oblique Triangle A Z N, we have

Z N, the *Co-Latitude* of the Place Z.

A N, the *Co-Latitude* of the Place A.

A N Z, the Difference of Longitude of A and Z.

A Z N, the Bearing of A from Z. the [illegible] from

A Z, the Diſtance of the two Places. [illegible]

Z A N, the Angle of *Poſition*.

11. Laſtly, In NAVIGATION, Problems of *oblique Sailing* do frequently occur, and require the Solution of Caſes depending upon the ſpherical oblique Triangle A Z N; in which

Z N, is the *Co-Latitude* of the Port, or Ship Z.

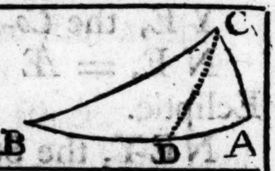
A N, the *Co-Latitude* of the Port A.

A Z, the Diſtance ſailed.

A N Z, the Difference of Longitude.

A Z N, the Angle of the Courſe.

12. In all *Right-angled Spherical Triangles* ABC, any two Parts being known, the reſt are eaſily found by the following Analogies, wrought by the common *Gunter*, or Sliding-Rule.

Caſes	Parts Given	Parts Sought	Analogies 
I	AB B	AC BC C	*R : sBA :: tB : tAC. R : csB :: ctAB : ctBC. R : csAB :: sB : csC.
II	AC B	AB BC C	tB : tAC :: R : sAB. sB : sAC :: R : sBC. csAC : R :: csB : sC.
III	BC B	AB AC C	R : csB :: tBC : tAB. R : sBC :: sB : sAC. csBC : R :: ctB : tC.
IV	AB AC	BC B C	R : csCA :: csAB : csBC. sAB : R :: tAC : tB. sAC : R :: tAB : tC.
V	BC AC	AB B C	csAC : R :: csBC : csAB. sBC : R :: sAC : sB. tBC : R :: tAC : csC.
VI	B C	AB AC BC	sB : csC :: R : csAB. sC : csB :: R : csAC. tC : ctB :: R : csBC.

13. An *Oblique Angled Spherical Triangle* BCD, is reduced to two Right Angled

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* In theſe Analogies, s ſtands for *Sine*, cs for *Co-ſine*; t for *Tangent*, and ct for *Co-tangent*.

ones A B C, and A C D, by letting a Perpendicular A C, fall from an Angle C to the oppoſite Side B D, and then if *three Parts* of ſuch a Triangle be given, the *other three* may be found by the foregoing Table of Analogies duly applied to theſe two Right-angled Triangles; for Inſtance, ſuppoſe the two Angles B and D, together with the Side B C were given, to find the Side C D; then in the Right-angled Triangle B C A, there is given the Angle B, and Side B C, whence the Perpendicular A C is found by the ſecond Analogy of Caſe III above. And now in the Right-angled Triangle A C D there is known the Angle at D, and the Side AC, to find the Side D C, which is known by the ſecond Analogy of Caſe II. And thus you proceed for any other Parts given or ſought.

14. But this Chapter is intended only for ſuch Readers as would be well acquainted with the Uſes of the GLOBE or SPHERE in *its fulleſt Extent*; and have been inſtructed in the firſt PRINCIPLES of *Spherical* GEOMETRY. To ſuch, nothing here delivered will be myſterious or difficult; but if they deſire a further *Eclairciſſement* on this Subject I ſhall take the Liberty of referring them once more to the INSTITUTIONS of *Spherical* TRIGONOMETRY in the *General* MAGAZINE *of* ARTS *and* SCIENCES; *viz.* from *Inſtitution* 1773 to 1866.

CHAP. VII.

Of the various ASTERISMS *and* CATALOGUES *of the* STARS, *in the* ZODIAC, *and in the Northern and Southern* HEMISPHERES.

1. THE Surface of the CELESTIAL GLOBE may be eſteemed a juſt and adequate Repreſention of the concave Expanſe of the Heavens, notwithſtanding the Objections of *Schickardus* and others to its Convexity; for 'tis eaſy to conceive the Eye placed in the Center of the Globe, and viewing the Stars on its Surface, ſuppoſing it made of Glaſs, as ſome of them are; and alſo, that if Holes were made in the Center of each Star, the Eye in the Center of the Globe, properly poſited, would view through each of thoſe Holes the very Stars in the Heavens repreſented by them.

2. Becauſe it would be impoſſible to have any diſtinct or regular Ideas or Notions of the Stars in reſpect of their Number, Magnitude, Order, Diſtances, *&c.* without firſt reducing them to proper Claſſes, and arranging them in certain Forms, which therefore are called ASTERISMS or CONSTELLATIONS; this was done in the early Ages of the World by the firſt Obſervers of the Heavens, and thoſe who made Spheres or Delineations; of whom Sir *Iſaac Newton* reckons *Chiron*, the Centaur, the firſt who formed the Stars into Conſtellations, about the Time of the *Argonautic Expedition*, or ſoon after; and that the ſeveral Forms or *Aſteriſms* were, as it were, ſo many ſymbolical Hiſtories, or Memorials of Perſons and Things remarkable in that Affair. Thus *Aries*, the Ram, is commemorated for his *Golden Fleece*, and was made the firſt of the Signs, being the Enſign of the Ship in which *Phryxus* fled to *Colchis*. *Taurus*, the Bull, with brazen Hoofs, tamed by *Jaſon*; *Gemini*, the Twins, *viz.* *Caſtor* and *Pollux*, two of the *Argonauts*; the Ship *Argo*, and *Hydrus* the Dragon, *&c.* which all manifeſtly relate to the Affairs of that Expedition, which happened about forty or fifty Years after *Solomon*'s Death.

3. By this Means they could make Catalogues of the Stars, record their Places in the Heavens, and call them all by their Names. *Hipparchus* is ſaid to be the firſt

who framed a Catalogue of the Stars, which was afterwards copied by *Ptolemy*, and adjuſted to his own Time, *A. D.* 140. The Number in this was 1026. After this *Ulug Beigh* made a Catalogue of 1022, reduced to the Year 1437. *Tycho Brahe* rectified the Places of 1000 Stars; but his Catalogue, publiſhed by *Longomontanus*, contains but 777, for the Year 1600. *Bayer* publiſhed a Catalogue of 1160. *Hevelius* compoſed a Catalogue of 1888 Stars, adjuſted to the Year 1660. But the largeſt and moſt compleat of all is the *Britiſh* Catalogue by Mr. *Flamſteed*, containing about 3000, of which ſcarce 1000 can be ſeen by the naked Eye in the cleareſt and darkeſt Night. They are rectified for the Year 1689. They are diſtinguiſhed into ſeven Degrees of Magnitude, in their proper Conſtellations; whoſe Names, together with the Number of Stars in each, and of each particular Magnitude, here follow, as I have taken them from the third Volume of the *Hiſtoria Cæleſtis*.

4. The *Conſtellations* of the TWELVE SIGNS.

Names.	N°.	Magnitude.						
		1	2	3	4	5	6	7
Aries.	65	0	1	2	5	6	28	23
Taurus.	135	1	1	4	13	21	44	51
Gemini.	79	1	2	4	6	12	32	22
Cancer.	71	0	0	0	6	7	39	19
Leo.	95	2	2	6	15	10	50	10
Virgo	89	1	0	5	10	19	45	9
Libra.	49	1	2	7	5	11	21	2

Scorpio.

Scorpio.	51	0	2	2	12	5	25	5
Sagittarius.	50	0	1	5	6	11	23	4
Capricornus.	51	0	0	3	3	9	34	2
Aquarius.	99	1	0	4	7	31	50	6
Piſces.	109	0	0	1	6	27	54	21

5. The *Conſtellations* of the NORTHERN HEMISPHERE.

Andromeda.	66	0	3	2	12	13	34	2 neb.
Aquila cum Antinoo.	70	1	0	10	7	15	32	5
Anſer cum Vulpe.	34	0	0	0	4	12	18	0
Auriga.	68	1	2	1	10	18	31	5
Bootes.	55	1	0	8	10	11	17	8
Caſſiopeia.	56	0	0	5	7	9	30	5
Cameloparدus.	58	0	0	0	4	18	27	9
Cepheus.	35	0	0	3	7	8	14	3
Coma Berenices.	40	0	0	0	8	14	14	4
Corona Septen.	21	0	1	0	6	8	6	0
Cygnus.	107	0	1	6	21	31	48	0
Delphinus.	18	0	0	6	0	2	9	1
Draco.	49	0	1	7	8	13	19	1
Equuleus.	10	0	0	0	4	1	5	0
Hercules.	95	0	0	11	15	31	38	0
Leo Minor.	53	0	0	1	5	11	33	3
Lacerta.	16	0	0	0	3	6	7	0
Lynx.	44	0	0	0	3	12	21	8
Lyra.	21	1	0	2	2	5	11	0
Perſeus. C. M.	67	0	2	5	11	15	28	6
Pegaſus.	93	0	4	3	10	13	58	5
Sagitta.	23	0	0	0	4	1	18	0
Serpens Ophiuchi.	59	0	1	7	6	3	32	10
Scutum.	7	0	0	0	2	4	1	0
Serpentarius, or *Opiuchus.*	69	0	1	7	15	13	26	7
Triangulum.	15	0	0	0	3	1	7	4
Urſa Major.	215	0	6	5	35	58	91	20
Urſa Minor.	24	0	0	4	3	5	6	6
Canes Venatici.	25	0	1	0	2	5	14	3

6. *Conſtellations in the* SOUTHERN HEMISPHERE.

Ara cum Thuribulo.	9	0	0	1	6	2	0	0
Argo, or *Navis.*	25	0	0	4	6	6	9	0
Apus.	11	0	0	0	4	3	4	0
Canis major.	32	1	7	1	4	11	5	3
Canis minor.	15	1	0	1	0	3	9	1
Cetus.	78	0	2	6	13	9	44	4
Centaurus, cum Lupo.	13	0	1	0	5	6	1	0
Cameliontis.	10	0	0	0	0	9	1	0
Columba Noabi.	10	0	2	0	1	6	1	0
Corona Auſtr.	12	0	0	0	1	3	8	0
Corvus.	10	0	0	3	2	2	3	0
Crater.	11	0	0	0	8	2	2	0
Eridanus.	68	0	0	12	15	20	20	1
Grus.	3	0	0	0	2	1	0	0
Hydrus.	10	0	0	4	2	3	1	0
Lepus.	19	0	0	3	7	3	6	0
Muſca.	4	0	0	0	2	2	0	0
Monoſceros.	19	0	0	0	10	7	2	9
Orion.	80	2	4	4	25	20	25	0
Pavo.	14	0	1	3	5	4	1	0
Phœnix.	13	0	1	5	6	1	0	0
Piſcis volans.	8	0	0	0	0	7	1	0
Robur Carolinæ.	12	0	1	2	7	2	0	0
Sextans.	41	0	0	0	1	7	32	1
Toucan.	9	0	0	4	2	3	0	0
Triangulum.	5	0	1	2	0	2	0	0
Xiphias.	6	0	0	1	2	1	2	0

	Num	1	2	3	4	5	6	7
7. In the *Zodiac*,	943	7	11	43	94	169	445	174
In the *Northern Hemiſph.*	1511	4	23	93	227	356	695	113
In the *Southern Hemiſph.*	547	4	20	56	136	145	176	10
Sum of all the STARS.	3001	15	54	192	457	670	1,316	297

8. The Uſe of ſuch a Catalogue of Stars is very great; for from hence we learn, (1.) If any *new Stars* at any time appear, which have never been obſerved before. (2.) If any Star, which now appears, ſhall in Time to come diſappear. (3.) If the *new Star* which ſhall appear be the ſame with a Star that has diſappeared formerly; and therefore, (4.) If the Stars have any periodical Times of Apparition. Hence (5.) The Means or Method of predicting the Appearing or Diſappearing of Stars. (6.) By a Catalogue of the Stars we compare their reſpective Places, Situations, and Diſtances with Eaſe. (7.) By this Means we alſo compare and determine the true Places and Motions of the heavenly Bodies in general, and of the Sun, Moon, Planets, and Comets in particular, with many other uſeful Purpoſes it ſerves beſides.

9. Now it is actually Fact, that ſome new Stars appear, and that others diſappear; yea, that they change their apparent Magnitude, and diſappear by degrees. *Hipparchus* the firſt of Men obſerved a new Star, (120 Years before *Chriſt*) which occaſioned his making a Catalogue of the Stars. Another is ſaid to have appeared *A. D.* 130; another *A. D.* 389; one exceeding bright in the 9th Century, and another in the Year 1264.

10. But the firſt *new Star*, of which we have any good Account, is that in the Chair of *Caſſiopeia*, firſt obſerved by *Cornelius Gem-*

ma on the 9th of *November* 1572, and by *Tycho Brahe* on the 11th. Sir *Iſaac Newton* ſays it equalled *Venus* in Brightneſs at its firſt Appearance, and gradually declined in its Luſtre, till it totally diſappeared in the *March* following. This Star is ſuppoſed to be the ſame that appeared in the Years 945 and 1264, having its Period about 310 or 320 Years.

11. In *Aug.* 13, 1596, *D. Fabricius* obſerved another *new Star* in the *Neck of the Whale*; and through the 17th Century this Star was obſerved to appear and diſappear periodically, its Period being equal to 333 Days. The Phænomena of this, and the like Stars, are ſuppoſed to be owing to the Spots on their Surface, which ſometimes increaſe and ſometimes decreaſe, in the manner as we have obſerved they do on the Surface of our Sun.

12. The different apparent Magnitudes of the Stars are owing to their different Diſtances from us. Had we Teleſcopic Eyes, we ſhould ſee many more. *Seventy Stars*, and more, have been diſcovered in the *Pleiades*, commonly called the *Seven Stars*; and all that Tract of the Heavens called the *Milky Way* (or *Galaxy*) is well known to be owing to the Refulgence of a prodigious Multitude of Stars diſſeminated thro' thoſe Parts of the Univerſe, tho' at ſo great a Diſtance as to be inviſible to the naked Eye; yet are they diſcernible in great Numbers thro' a Teleſcope,

and more in Proportion as the Inſtrument is better. But for the almoſt infinite (at leaſt, inconceivable and immenſe) Diſtance of the neareſt fixed Star, the Reader may ſee a Calculation in the *Philoſoph. Britan.* Vol. 3. P. 263, Edit. 2d.

13. Hence likewiſe we account for that particular Phænomenon we call a *nebulous Star*, or cloudy faintiſh light Spots that appear like Stars in an indirect View; for in order to this you have no more to do than only to direct a good Teleſcope to any one of them, and you will be agreeably ſurprized with a View of a great Multitude of very ſmall Stars, which were the Cauſe of the *luminous Spot* to the naked Eye.

14. To the very ſmall apparent Magnitude of the Stars we owe their conſtant *Twinkling*; for being but lucid Points, every opake Corpuſcle or Atom floating in the Air will be big enough to cover and eclipſe them, when they get in the Right Line connecting the Star and the Eye; which Alternations of momentary Occultations and Apparitions make the Twinkling of the Stars we now ſpeak of.

FINIS.

A Table *of the* Right Aſcenſion *and* Declination *of the principal* fixed Stars, *rectified for the Beginning of the Year* 1758.

The Names of the Stars, their Mark in Bayer, and their Magnitude.		Rt. Aſcenſion.			Declination.		
		D.	*M*	*S.*	*D.*	*M.*	*S.*
Algenib in Pegaſus.	γ 2.	0	11	17	13	49	56 N.
The Breaſt of Caſſiopeia.	α 3.	6	42	51	55	11	58 N.
The Tail of the Whale.	β 2.	7	50	45	19	19	23 S.
The Polar Star.	α 2.	10	57	57	88	0	18 N.
The Girdle of Caſſiopeia.	γ 3.	10	33	20	59	23	37 N.
The Girdle of Andromeda.	β 2.	14	0	49	34	19	31 N.
In the Ear of Aries.	γ 4.	25	1	25	18	5	40 N.
The preceding Horn of Aries.	β 3.	25	16	49	19	36	41 N.
The Foot of Andromeda.	γ 2.	27	16	15	41	9	5 N.
The bright Star of Aries.	α 2.	28	22	55	22	18	13 N.
The Whale's Mouth, *Mencar*	α 2.	42	24	1	3	7	16 N.
Meduſa's Head.	β 2.	43	6	47	40	0	0 N.
The bright Star of Perſeus.	α 2.	46	46	42	48	58	22 N.
The Bull's Eye. Aldebaran	α 1.	65	30	3	16	0	1 N.
The Goat Star, Capella.	α 1.	74	41	38	45	43	14 N.
The Foot of Orion.	β 1.	75	43	15	8	30	3 S.
The northern Horn of Aries.	β 2.	77	44	4	28	22	36 N.
The weſtern Shoulder of Orion.	γ 2.	78	1	40	6	6	25 N.
The firſt of Orion's Girdle.	δ 2.	79	53	16	0	29	59 S.
The ſecond.	ε 2.	80	58	30	1	22	39 S.
The third.	ζ 2.	82	7	52	2	5	30 S.
Auriga's Shoulder.	β 2.	85	25	40	44	53	28 N.
Orion's eaſtern Shoulder.	α 1.	85	30	26	7	20	21 N.
Bright Star in the Foot of Gemini.	γ 2.	95	55	0	16	35	2 N.
The great Dog-Star, Sirius.	α 1.	98	36	42	16	23	57 S.
The northern Head of Gemini.	α 2.	109	45	49	32	23	48 N.
The little Dog-Star, Procyon.	α 2.	111	38	36	5	49	51 N.
The ſouthern Head of Gemini.	β 2.	112	36	19	28	35	29 N.
Hydra's Heart.	α 2.	138	54	50	7	36	58 S.
The Lion's Heart, Regulus.	α 1.	148	51	6	13	8	44 N.
In the great Bear.	β 2.	161	45	0	57	40	38 N.
In the great Bear.	α 2.	162	7	33	63	3	21 N.
The Tail of the Lion.	β 2.	174	9	45	15	55	47 N.
In the Thigh of the Bear.	γ 2.	175	13	47	55	2	41 N.
In the great Bear.	δ 3.	180	49	27	58	22	59 N.
The firſt Star in the Tail of the Bear.	ε 3.	190	48	48	57	16	57 N.
The Virgin's Wing.	ε 3.	192	31	7	12	16	17 N.
The Virgin's Spike.	α 1.	198	6	22	9	53	4 S.
The 2d Star in the Tail of the great Bear.	ζ 2.	198	31	11	56	11	59 N.
The 3d Star in the great Bear's Tail.	η 2.	204	29	11	50	31	58 N.
Arcturus.	α 1.	211	8	57	20	27	39 N.
The South Scale of Libra.	α 2.	219	22	8	15	0	58 S.
The firſt Shoulder of the Bear.	β 2.	222	55	5	75	8	53 N.
The North Scale of Libra.	β 2.	225	59	37	8	28	8 S.
The bright Star in the Crown.	α 2.	231	5	15	27	32	50 N.
The bright Star in the Serpent's Neck.	α 2.	233	4	56	7	12	25 N.
The northern Star in Scorpio's Forehead.	β 2.	237	49	39	19	7	10 S.

The

The Names of the Stars, their Mark in Bayer, and their Magnitude.		Rt. Aſcenſion.			Declination.			
		D.	*M.*	*S.*	*D.*	*M.*	*S.*	
The Heart of Scorpio.	α 1.	243	38	17	25	52	11	S.
The Knee of the Serpentarius.	ζ 3.	245	57	5	10	3	13	S.
The Head of Hercules.	α 3.	255	53	37	14	41	10	N.
The Head of Serpentarius.	α 2.	260	54	57	12	45	25	N.
The bright Star in the Dragon's Head.	β 3.	261	14	29	52	29	23	N.
The Serpent's Shoulder.	β 3.	262	52	7	4	41	23	N.
The bright Star in the Dragon's Head.	γ 3.	267	45	55	51	31	32	N.
The ſouthern Bow of Sagittarius.	ε 3.	272	0	40	34	28	13	S.
Bright Star of Libra.	α 1.	277	10	43	38	34	17	N.
The Shoulder of Sagittarius.	σ 3.	280	2	46	26	34	27	S.
The bright Star of Aquila.	α 2.	294	43	52	8	14	43	N.
The Horn of Capricorn.	β 2.	301	49	59	15	31	49	S.
Tail of the Swan.	α 2.	308	17	13	44	35	20	N.
The preceding Shoulder of Aquarius.	β 3.	319	41	27	6	37	35	S.
Pegaſus's Mouth.	ε 3.	323	3	31	8	46	22	N.
Star in the Tail of Capricorn.	δ 3.	323	23	58	17	12	56	S.
Scheat in Aquarius.	δ 3.	340	25	53	17	6	28	S.
Fomalhaut.	α 1.	341	2	32	30	54	12	S.
Scheat in Pegaſus.	β 2.	343	0	18	26	46	7	N.
Markab, ditto.	α 1.	343	10	11	13	54	10	N.
Andromeda's Head.	α 2.	358	58	5	27	44	52	N.
Bright Star in Caſſiope's Chair.	β 2.	359	5	0	57	48	27	N.

N. B. This is the Table referred to in the Note Page 88, and was forgot to be inſerted at the End of that Chapter.

Alſo, having accidentally omitted to reviſe and correct one half Sheet of this Work, the following Errata have eſcaped, which it is neceſſary here to appriſe the Reader of, and are as follow, *viz.*

ERRATA.

In Page 46, for *Azimuth* read *Altitude*. P. 48, for 20th of *Gemini* r. 21ſt of *Taurus*. P. 49. for 25 r. 35. P. 50, for 22° 30′ of *Taurus* r. 29° of *Aries*. *Ibid.* for 29° r. 2° 30′. P. 51, for 20 r. 21; for 19° 30′ r. 10°, and for 17° r. 44° 30′.

2.2.04.

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